APPENDIX H
Hydrology and Water Quality, Section 3.2 and Appendix C of Draft EIR

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3.2 Hydrology and Water Quality

3.2.1 ENVIRONMENTAL SETTING

Overview

Project Area

The proposed project includes groundwater pumping from wells located in Rose Valley, which is situated in the southeastern California desert. The project area is shown in Figure 1.1-1. The project also includes installation of 9 miles of pipeline for delivery of the pumped groundwater to the Coso geothermal field in the Coso Range, east of the Rose Valley.

The project area lies within an arid desert region that receives about 6 inches of precipitation per year. Surface water is limited; however, the alluvial valley includes a groundwater aquifer that is recharged from precipitation in various surrounding sources, including the Sierra Nevada Mountains.

This section of the EIR includes a description of the existing surface water and groundwater resources and water quality in the project area and region. The geothermal resource on CLNAWS is also described.

Methods

The assessment of surface water and groundwater hydrology and water quality presented in this section is based on several previously prepared studies and reports, as well as studies performed specifically for the proposed project.

Existing Reports and Studies. Many sources of information on local and regional hydrology and geohydrology have been referenced and used in preparation of this hydrology section. The primary sources include:

- *The Hydrology of the Rose Valley and Little Lake Ranch, Inyo County, California* (Bauer 2002). This report includes a detailed analysis of the hydrology of Little Lake, a perennial lake with surrounding ponds, located about 9 miles south of the proposed project site. The report includes research and results of survey work at the lake to characterize the groundwater system in the area. Data and analysis pertaining to the understanding of the hydrology of the groundwater systems in Rose Valley and in particular, Little Lake, have been incorporated in this section of the EIR.
- *Hydrogeologic and Hydrochemcial Framework of Indian Wells Valley, California: Evidence for Interbasin Flow in the Southern Sierra Nevada* (Williams 2004). This report describes the geohydrologic characteristics of the Indian Wells Valley, which is directly south of the Rose Valley. It also includes data on groundwater chemistry and chemical isotope analysis for water flowing into Indian Wells Valley, including from the Rose Valley. Data on chemical isotope sourcing for water in Little Lake are included in this report and were used in the setting and analysis of this EIR section.

Consultants for the Coso Operating Company (COC) previously performed groundwater testing and modeling for the proposed project. These studies have been reviewed and used as appropriate to describe the setting and to analyze the project impacts. The reports on the previous groundwater modeling efforts include:

- *Results of Aquifer Tests, Hay Ranch Production Wells, Rose Valley, Coso Junction, California* (GeoTrans 2003). Pumping tests were conducted in 2003 by GeoTrans using the two Hay Ranch production wells. The aquifer tests consisted of: 1) pumping the south Hay Ranch well at a rate of approximately 2,006 gpm for 24 hours beginning on

September 10, 2003, followed by recovery monitoring for a period of 29 hours; and, 2) pumping the north Hay Ranch well at a rate of approximately 2,040 gpm for 24 hours beginning on September 13, 2003 followed by recovery monitoring for a period of approximately 21 hours.

- *Rose Valley Groundwater Model* (Brown and Caldwell 2006). This report describes the initial groundwater model prepared for the Hay Ranch project. The consulting firm Brown and Caldwell was retained by COC to develop a groundwater flow model for the Rose Valley groundwater basin. The model was based on data and interpretations from previous studies and compilations of available geological, geophysical, and hydrological data. The groundwater flow system was defined, flow components identified, and the magnitude of each was estimated in this report. A conceptual water budget was then established. Upon completion of the conceptual model, a three-dimensional numerical groundwater flow model for the Rose Valley was developed using MODFLOW (McDonald and Harbaugh 1988). The model was first calibrated by simulating the steady-state groundwater system conditions in the Rose Valley and then used in a predictive mode to assess the potential impact of the proposed project's groundwater withdrawal on the Rose Valley's subsurface flow system.

The description and analysis of the geothermal resource and Coso Hot Springs are based on several documents, including:

1) Coso Hot Springs Monitoring Report (Geologica 2004-2007)
2) Hydrological Analysis of the Coso Geothermal System: Technical Summary (ITSI 2007)
3) Geologic History of the Coso Geothermal System (Adams et al. June, 2000)

Additional Studies Performed for the Proposed Project. Additional studies were conducted to analyze the project effects as a part of this EIR process, including:

1) A groundwater pumping test on the proposed water supply wells for the project to supplement the data gathered during the pumping test performed in 2003 by GeoTrans
2) A recalibration of the Brown and Caldwell (2006) MODFLOW model
3) Testing and analysis of water isotope, chemistry, and drinking water quality

Several issues were identified with the performance and analysis of the 2003 pumping tests, including the issue that only the two wells on the Hay Ranch property were monitored during the pumping test, that the test duration was limited to 24 hours, and that the groundwater levels in the Hay Ranch wells had not fully recovered to their pre-pumping levels from the testing of the south well when the north well testing began. Review of the data collected in the testing of the south well suggests that the aquifer continued to recover from the testing of the south well during the entire duration of the testing of the north well. As a result, data from testing of the north well could not be evaluated reliably using the graphical methods presented in the GeoTrans (2003) report.

To address these deficiencies, a long term pumping test was performed and analyzed for this EIR in order to:

1) Produce additional data that allowed better definition of the existing groundwater reservoir and better calibration of the numerical model;
2) Provide a basis for more defensible forecasts of long term aquifer behavior using the numerical model (better impact analysis); and
3) Provide data to use in the numerical model to develop monitoring and mitigation measures such as "trigger levels" and monitoring locations.

The pumping test was performed over a period of 20 days from November 17, 2007 to December 6, 2007. The pumping test report is included in Appendix C1. The test included installing a temporary pump in the existing Hay Ranch south well, pumping groundwater at a rate of approximately 2,000 gallons per minute for a period of 14 days, and monitoring groundwater levels at various locations throughout Rose Valley for 20 days. The groundwater level monitoring program consisted of a combination of long term and short term monitoring conducted before, during, and after the pumping test, depending on well access and operational constraints. COC utilized existing agriculture and drinking water supply wells owned by various parties, including COC, for pumping test monitoring. No new wells were constructed for the test. The locations of the monitoring wells and the results of the test are presented in Appendix C1.

Results of the pumping tests were then used to recalibrate the Brown and Caldwell (2006) MODFLOW groundwater flow model to:

- Evaluate groundwater conditions;
- Analyze the potential impacts to groundwater resources in Rose Valley; and
- Define mitigation measures to reduce potentially significant effects of the construction and operation of the proposed COC Hay Ranch project.

The model recalibration process and application of the model to impact analysis are described in Appendix C2.

In addition to compiling and integrating available water chemistry and isotope data from Rose Valley waters into a database, six water samples were collected and analyzed to help understand the groundwater flow system. Samples from the Hay Ranch south well, Coso Junction #2 well, Davis Spring at Portuguese Bench, Little Lake north well, and Coso Spring were analyzed for stable isotopes of oxygen and hydrogen in water (oxygen-18 and deuterium) at Isotech Laboratories. Chloride, boron and total dissolved solids were analyzed at Zalco Laboratories. One sample from the Hay Ranch south well was collected by COC and analyzed for drinking water standard analytes (inorganic and general chemical) at Zalco Laboratories.

Climate and Physiography

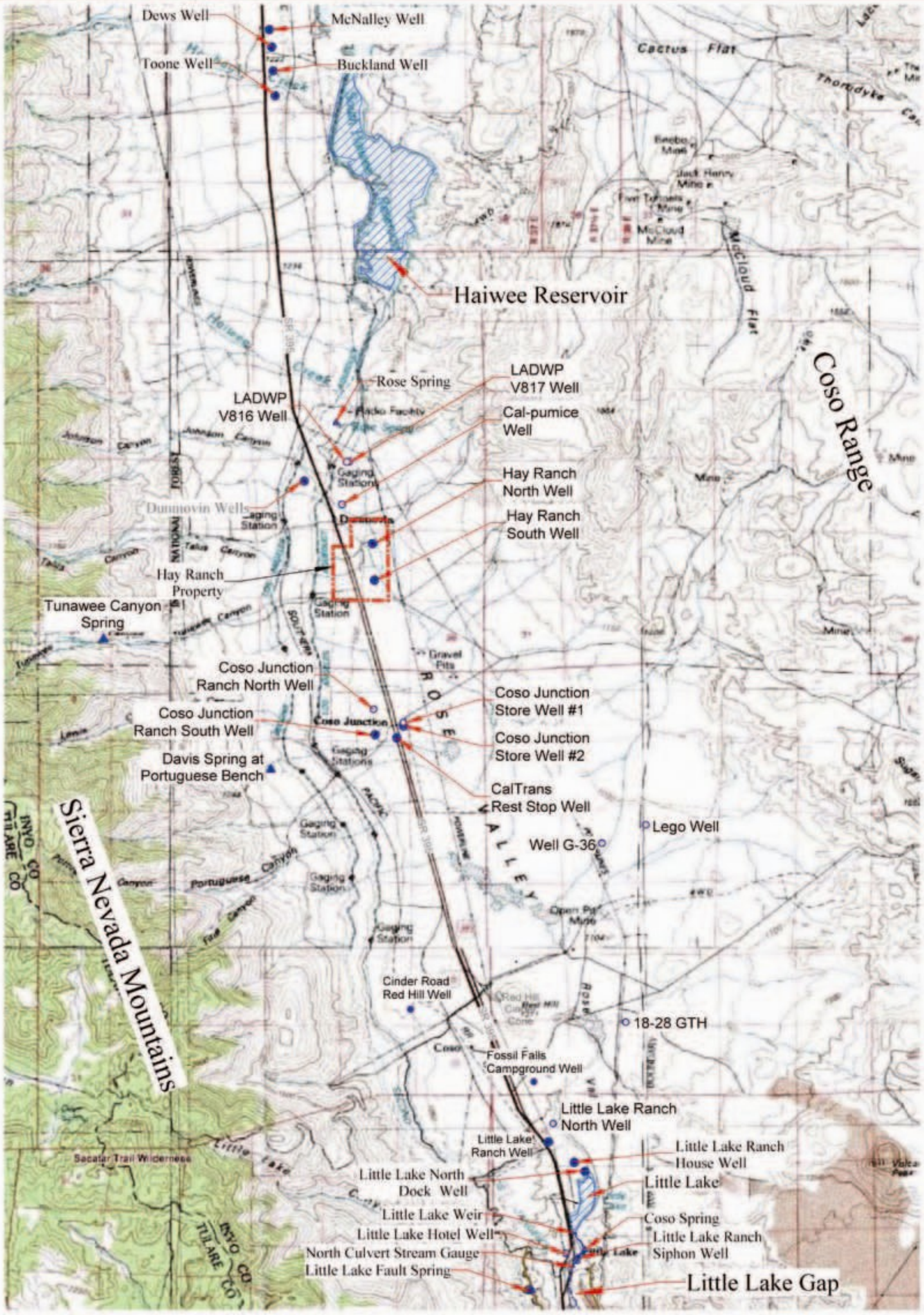
Rose Valley is a long, narrow valley located on the eastern flank of the Sierra Nevada Mountains in Inyo County, California. The ground surface of the valley floor slopes gently to the south at a rate of 30 to 35 feet per mile. The alluvial portion of the groundwater basin is approximately 16 miles long from the southern end of the Haiwee Reservoir to just south of Little Lake and has a maximum width of approximately 6 miles at its widest point. Rose Valley is topographically separated from the Owens Valley (north of Rose Valley) by Dunmovin Hill, a topographic high that is composed of a massive landslide or series of debris flow deposits that originated from the Sierra Nevada range to the west (Bauer 2002). Rose Valley is separated from the Indian Wells Valley (south of Rose Valley) by a topographic high formed by a combination of granitic rocks and volcanic flows, and by the Little Lake Gap, which is an approximately 1,000 feet wide water-carved canyon incised within the volcanic bedrock (Bauer 2002). Figure 3.2-1 shows the physiographic features of the project area.

The average annual precipitation in Rose Valley ranges from 5 to 7 inches, while the area’s open potential water evaporation rate has been estimated to be up to 65 to 80 inches per year (CWRCB 1993, Bauer, 2002). Evapotranspiration rates for soil and plants in the area are likely lower, based on investigations conducted in Owens Valley (Steinwand et al. 2006). Surface water bodies in the Rose Valley area consist of perennial springs sustained by groundwater flow, ephemeral streams and washes that mainly flow in the winter, and manmade lakes and reservoirs.

Surface Water

Surface water features of interest are shown on Figure 3.2-1. The principal surface water bodies in Rose Valley include:

Figure 3.2-1: Study Area Physiographic Features



SOURCE: Geologica 2008

LEGEND

Approximate Scale in miles: 0 1 2

- ▲ Spring or Siphon Well
- ● Pumping Well
- ○ Out-of-Use Well

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- South Haiwee Reservoir
- Several springs
- Little Lake and its associated springs, wetlands and ponds

Haiwee Reservoir

South Haiwee Reservoir is located at the north end of Rose Valley approximately 4 miles north of Hay Ranch (shown in Figure 3.2-1). The Los Angeles Department of Water and Power (LADWP) owns and operates Haiwee Reservoir as part of the Los Angeles Aqueduct system, which supplies drinking water to the Los Angeles area.

The crest of south Haiwee Dam is located at approximately 3,766 feet above mean sea level (amsl). Because of seismic stability concerns, the water level in the reservoir is currently limited to a maximum elevation 3,742 feet amsl. The water level in the reservoir typically rises during the winter rainy season. During a month-long period that included the Hay Ranch pumping test described in Appendix C1, the water level in the reservoir rose approximately 4 feet, from approximately 3,722 feet on November 1 to 3,726 feet on December 5, 2007.

Springs

Several springs are located in Rose Valley, including (Bauer 2002):

- Rose Spring located near Haiwee Reservoir
- Tunawee Canyon Spring
- Davis Spring located at Portuguese Bench
- Little Lake Fault Spring
- Coso Spring

Rose Spring is located approximately 2 miles south and west of the South Haiwee Reservoir. The spring is located at an elevation of approximately 3,600 feet amsl. Rose Spring is located on an east-facing slope above a wash. A concrete storage structure lies below the spring. Water pipes from the spring once fed the storage structure, but the piping system is no longer functional. No surface water was present during a biological reconnaissance survey conducted on April 5, 2008.

Tunawee Canyon Spring is located in Tunawee Canyon approximately 4 miles west and north of Coso Junction at an approximate elevation of 5,200 feet amsl. Several springs are identified in the upper reaches of Tunawee Canyon on the USGS topographic map of the area. The spring is likely sustained by high elevation precipitation infiltration in the Sierra Nevada Mountains to the west. No information regarding discharge rates from the spring was identified.

The Davis spring is located on the Davis Ranch, approximately 2 miles southwest of the Hay Ranch property. The Davis spring is located on the west-central side of Rose Valley at Portuguese Bench at an elevation of approximately 3,870 feet amsl. The groundwater discharge rate from the Davis spring, referred to as the Davis siphon well in Appendix C1, was measured during the November/December 2007 pumping test and ranged from 4.2 to 4.5 gallons per minute (gpm), or approximately 7 acre-feet/yr.

The Davis spring discharge is located more than 600 feet higher than the groundwater table in the Rose Valley aquifer east of the Davis property at Coso Junction. Spring flow is sustained by high elevation precipitation infiltration in the Sierra Nevada Mountains west of the Davis property. Monitoring of the spring discharge rate during the 2007 pumping test did not provide any evidence of impacts from pumping at Hay Ranch, based on spring flow measurements made at the time. Discharge from the spring that is not used on the Davis property infiltrates back into the ground and percolates downward to recharge the alluvial aquifer.

The Little Lake Fault Spring and Coso Spring are located at the south end of Rose Valley. Little Lake Fault Spring is located on the west side of Highway 395, approximately 1 mile south of Little Lake. Coso Spring is located on the east side of Highway 395, on the Little Lake Ranch property, approximately 0.25 miles south of Little Lake. No data have been identified regarding the groundwater discharge rate from the Little Lake Fault Spring. The Little Lake Fault Spring and Coso Spring are discussed further under the heading “Little Lake.”

Little Lake

Overview of Little Lake Surface Water Features. Little Lake is a man-made perennial lake located at the south end of Rose Valley approximately 9 miles south of the Hay Ranch property (Figures 3.2-1 and 3.2-2). Little Lake is located entirely within the Little Lake Ranch, which is a 1,200 acre privately-owned recreational preserve owned and managed by Little Lake Ranch, Inc.

A habitat restoration and improvement plan for Little Lake was prepared and approved on October 14, 2000. The plan included several wetland enhancement plans. A copy of the plan and the associated Mitigated Negative Declaration are included in Appendix E of this EIR.

The wetlands, riparian zone (interface between land and surface water), and open water habitat on the property currently include the 90-acre Little Lake, two perennial ponds (P-1 and P-2 on Figure 3.2-2), several other ponds that reportedly contain water intermittently, and adjacent wetland habitat. Little Lake is reportedly 3 to 5 feet deep; the depths of the other ponds are unknown. The configuration of ponds, springs, and wells at the Little Lake property are shown in Figure 3.2-2.

Little Lake and the surrounding wetland areas and ponds are fed by a combination of groundwater, submerged springs, and surface springs. At the southern end of Rose Valley, groundwater flow through the Little Lake Gap is constrained by bedrock on the east and west and an apparent subsurface bedrock rise below. The ground surface in the area slopes gently to the south between the northern property line and Little Lake, then more steeply south of Little Lake. As a result of the combination of south-sloping ground surface and bedrock barriers to lateral or vertical groundwater flow, groundwater in this area discharges to the surface. Some wetlands occur here naturally; however, the system is now manipulated for maintenance of the lake for recreational purposes and habitat enhancement efforts.

The only groundwater level data identified for the Little Lake Ranch property, collected in 1997 and 1998 (Bauer 2002), indicated that the groundwater elevation at the north end of the lake was approximately 3 feet higher than the lake level and that the lake gains water from the aquifer. Overflow from the Little Lake weir at the south end of the lake is conveyed to Upper Little Lake Pond (P-1) through an open channel.

Groundwater discharging from the Coso Spring, located approximately 0.25 miles south of Little Lake, also flows into Upper Little Lake Pond (P-1). A siphon well located south of Little Lake (below the elevation of Little Lake and Coso Spring) brings additional groundwater to the surface where it is piped to Lower Little Lake Pond (P-2). The discharge from both ponds flows through an open channel to the south where it is used to fill additional ponds when flow is adequate. No surface water flows off the Little Lake Ranch property (ULLR 2000).

The siphon well consists of a short vertical well screen and a 12-inch diameter discharge pipe. As long as the discharge pipe is full of water (“primed”), the pipe suctions groundwater from the vertical well screen. Little Lake Ranch staff can raise or lower the weir on Little Lake to control the discharge rate when the lake level is high enough to sustain discharge. Water usually does not flow from the lake in the summer and early fall months. There is no provision to manipulate the discharge rate from Coso Spring or the siphon well; both flow in accord with prevailing groundwater conditions. The flow rates of these features are not monitored and the elevations and locations of surface water features at Little Lake have not been surveyed.

Figure 3.2-2: Hydrologic Features of Little Lake Ranch

SOURCE: Geologica 2008

LEGEND

Scale in miles 0 0.5

▲ Spring or Siphon Well
● Pumping Well
○ Out-of-Use Well

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Relationship Between Groundwater Elevation, Lake Level, and Discharge Rate. Monitoring data collected by Bauer (2002) for a 14-month period between January 6, 1997 and March 21, 1998 provides some insight into the hydrologic system operating at Little Lake. These data are summarized in Table 3.2-1 and schematically illustrated on Figure 3.2-3. Bauer (2002) observed that the groundwater elevation in a monitoring well immediately north of Little Lake (now known as the Little Lake North Dock well) was consistently 3 feet higher than the lake level (see Figure 3.2-3) indicating that the lake gained water from the aquifer throughout the year (Bauer 2002). This elevation difference is maintained by a combination of evaporation from the lake surface, which removes water from the system, and discharge over the weir, which allows the water to flow south to lower elevation ponds on the property (otherwise the lake would equilibrate at the same level as the aquifer). As a result of habitat restoration efforts by Little Lake Ranch, some features, such as the configuration of the Little Lake weir, may differ from those observed by Bauer in 1997/1998.

As illustrated on Figure 3.2-4, groundwater level monitoring conducted by COC indicates that groundwater elevations have risen by approximately 2 feet in the last five years (since 2003) throughout the northern part of Rose Valley. The impact of the rising groundwater table on lake levels and discharge rates has not been documented but higher lake levels and higher discharge rates are likely.

Groundwater

Hydrostratigraphic Units

Hydrostratigraphic units are the geologic formations in which groundwater flows. The principal hydrostratigraphic units that comprise the Rose Valley aquifer are recent alluvial deposits and the Coso Lake Bed and Coso Sand Members of the Coso Formation. Older bedrock has much lower permeability and greatly impedes or excludes groundwater flow.

Groundwater Occurrence and Flow

The groundwater table in the Rose Valley project area ranges from 140 to 240 feet below ground surface (bgs) in the northern and central parts of Rose Valley to approximately 40 feet bgs at the northern end of the Little Lake Ranch property, near the southern end of the valley. A groundwater elevation contour map of Rose Valley, developed from depth to water measurements made on November 19, 2007, is presented on Figure 3.2-4 and tabulated in Table 3.2-2.

Groundwater generally flows to the southwest in the valley as evidenced during the pumping test conducted in November 2007. With one exception, the November 2007 monitoring results were consistent with observations reported by Bauer (2002) for data collected in 1998 for valley groundwater. Water level measurements in Navy well 18-28, located in southeastern Rose Valley (Figure 3.2-5), indicated that the groundwater elevation in this area was approximately 10 feet higher than expected. This well was not available for monitoring during previous investigations. The higher groundwater elevation is believed to be the result of impeded groundwater flow through the volcanic deposits south of the Red Hill cinder cone, towards Little Lake, and/or groundwater inflow from the Coso Basin to the northeast.

Because the ground surface slopes more steeply to the south of Rose Valley than the groundwater table, the groundwater table surfaces from springs beneath Little Lake, sustaining the lake and the surface water discharge across the Little Lake weir. Additional groundwater discharges from Coso Spring and the Little Lake Ranch siphon well as the ground surface dips more steeply to the south, south of Little Lake.

Table 3.2-1: Rose Valley EIR -Summary of Bauer (2002) Stream and Spring Flow Measurements

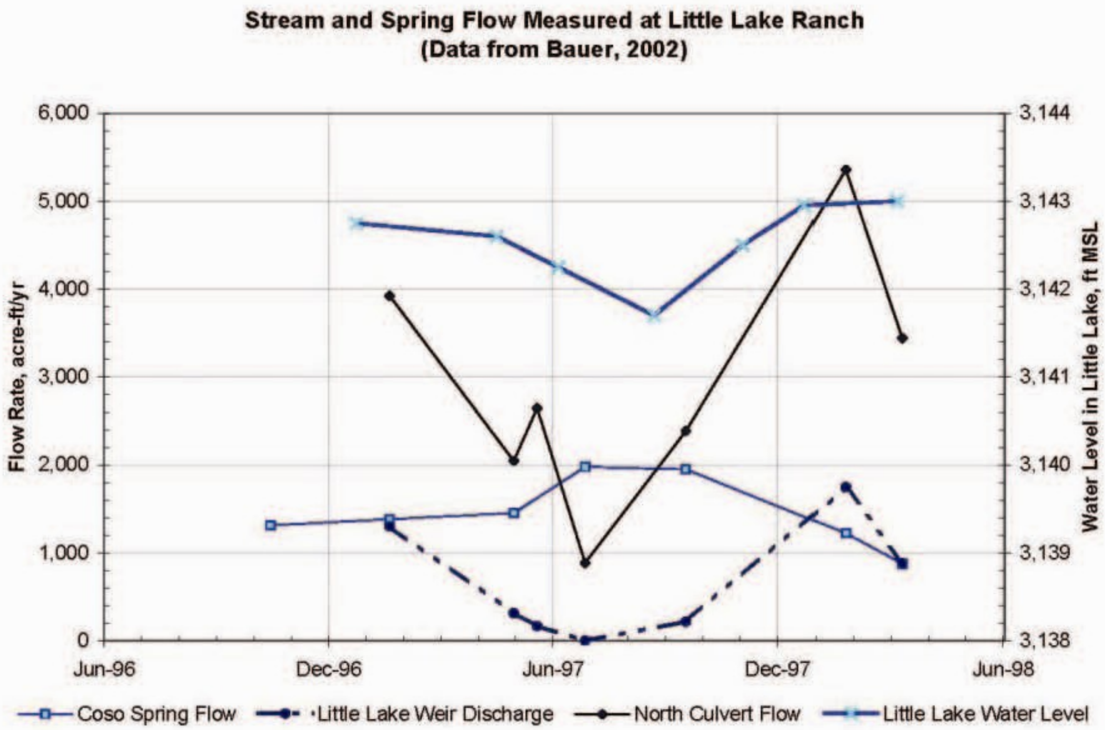
Location	Date Measured	Flow Rate, acre-ft/yr
Coso Spring	10/28/96	1,311
South Culvert (1)	10/28/96	318
Coso Spring	2/2/97	1,382
Little Lake Weir	2/2/97	1,299
North Culvert (2)	2/2/97	3,924
South Culvert	2/2/97	515
Coso Spring	5/14/97	1,451
Little Lake Weir	5/14/97	312
North Culvert	5/14/97	2,043
South Culvert	5/14/97	583
Little Lake Weir	6/2/97	166
North Culvert	6/2/97	2,646
South Culvert	6/2/97	676
Coso Spring	7/11/97	1,976
Little Lake Weir	7/11/97	0
North Culvert	7/11/97	885
South Culvert	7/11/97	428
Coso Spring	10/1/97	1,949
Little Lake Weir	10/1/97	217
North Culvert	10/1/97	2,384
South Culvert	10/1/97	627
Coso Spring	2/7/98	1,222
Little Lake Weir	2/7/98	1,746
North Culvert	2/7/98	5,357
South Culvert	2/7/98	1,866
Coso Spring	3/25/98	874
Little Lake Weir	3/25/98	887
North Culvert	3/25/98	3,439
South Culvert	3/25/98	917

NOTES:

(1) Most southerly surface water flow on the property.

(2) Flow rate in ditch discharging from lower Little Lake pond (P-2); should contain combined flow from Little Lake Weir, Coso Spring, and Siphon well.

Figure 3.2-3: Flow and Water Level Measurements at Little Lake



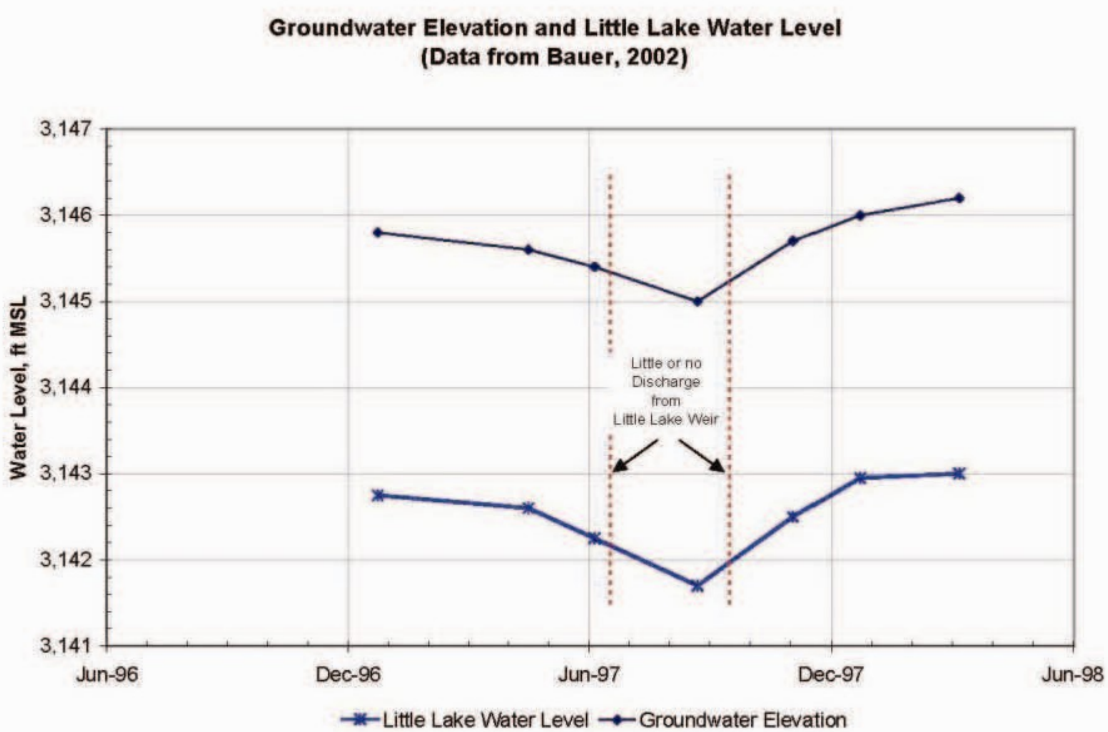


Figure 3.2-4: Groundwater Elevation Hydrographs

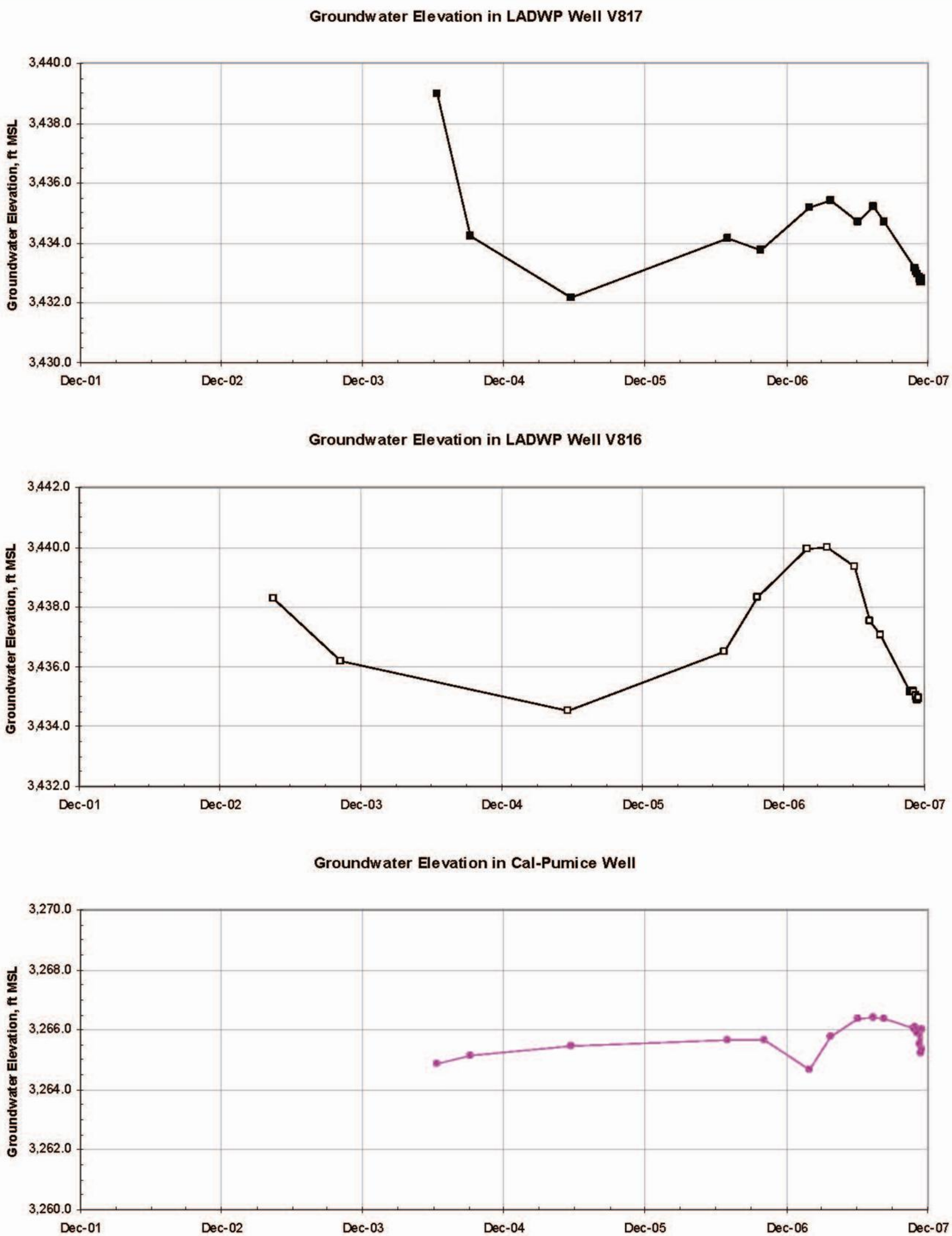


Figure 3.2-4 *(Continued)*: Groundwater Elevation Hydrographs

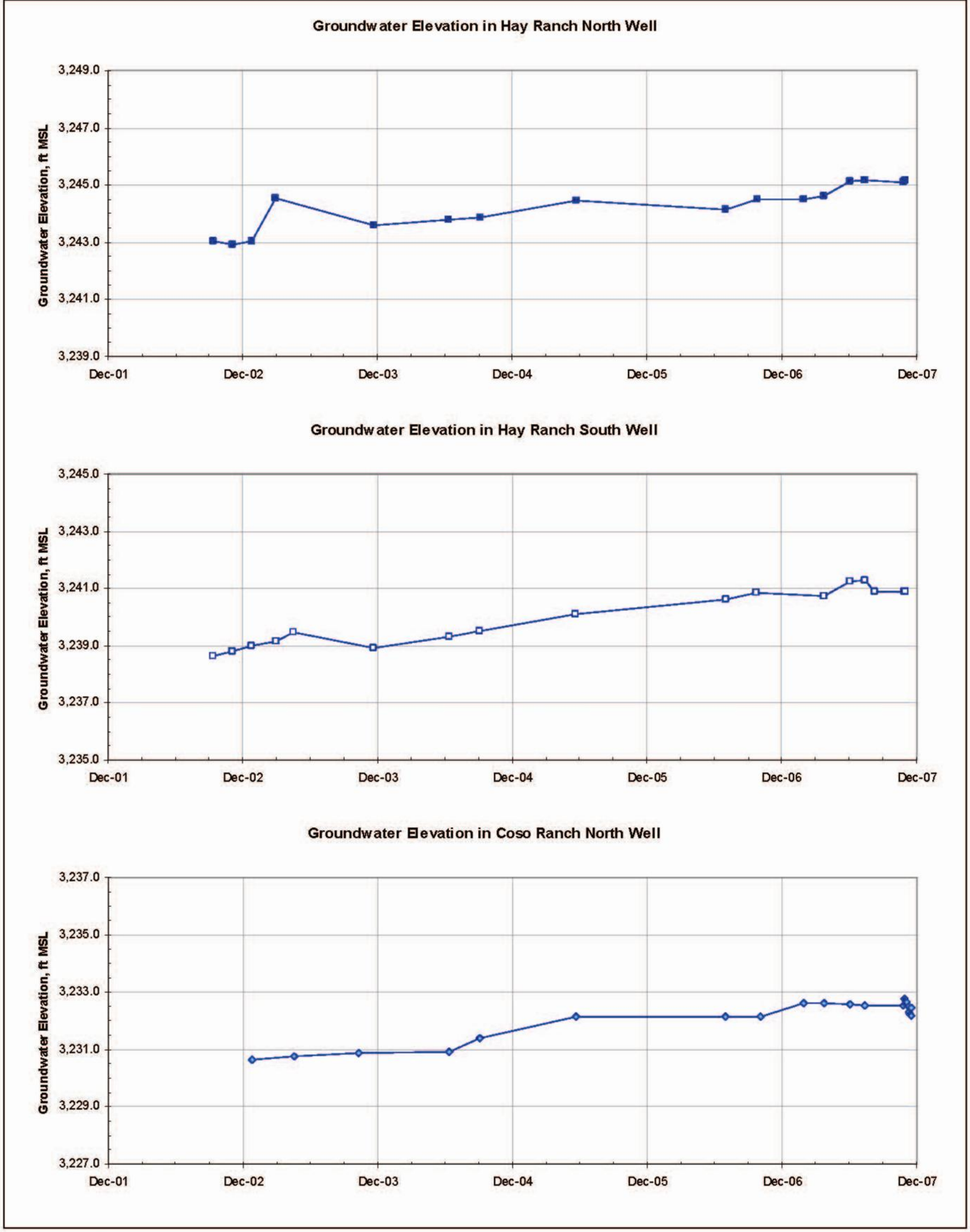
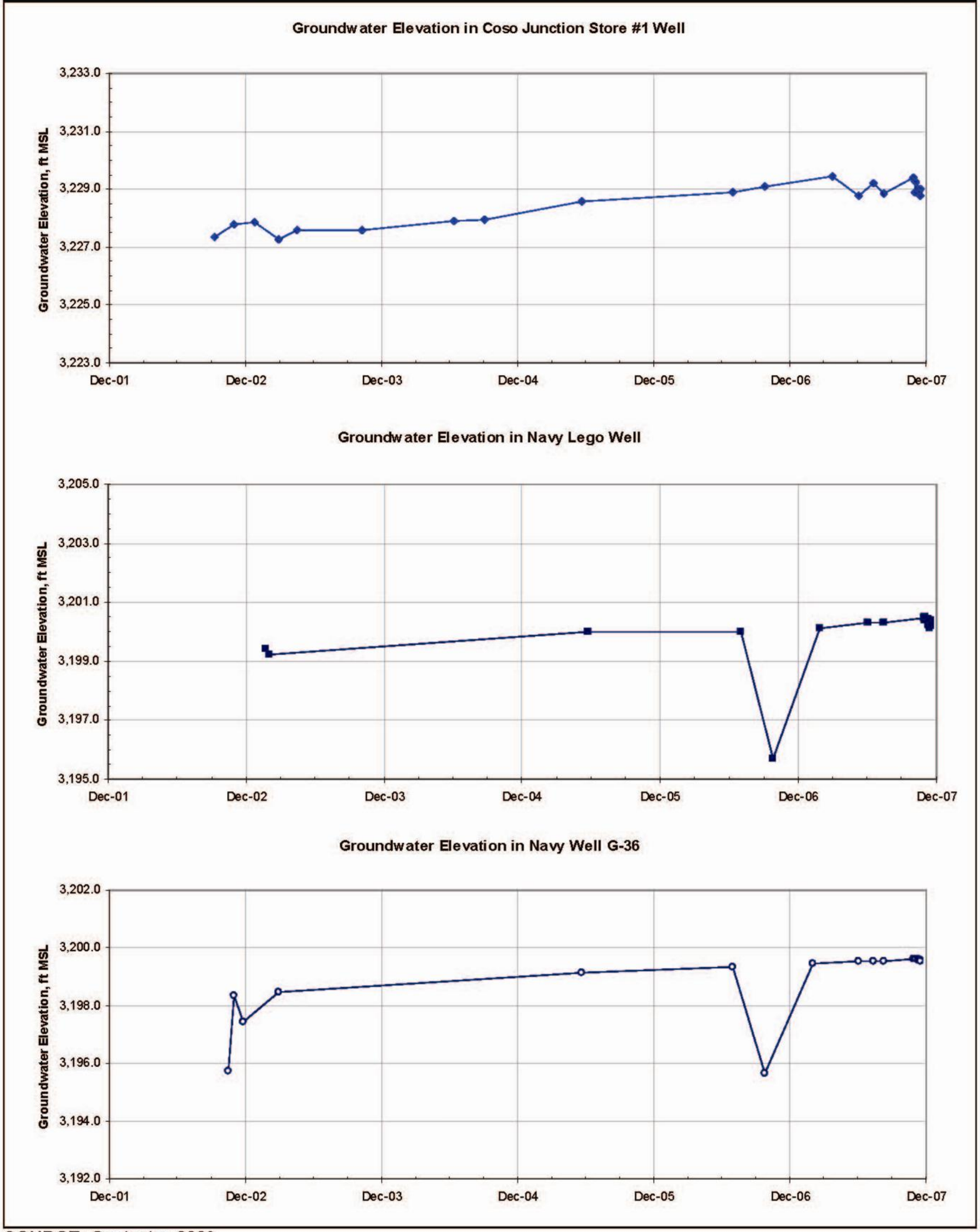


Figure 3.2-4 *(Continued)*: Groundwater Elevation Hydrographs



SOURCE: Geologica 2008

Table 3.2-2: Rose Valley EIR November 2007 Groundwater Elevation Data

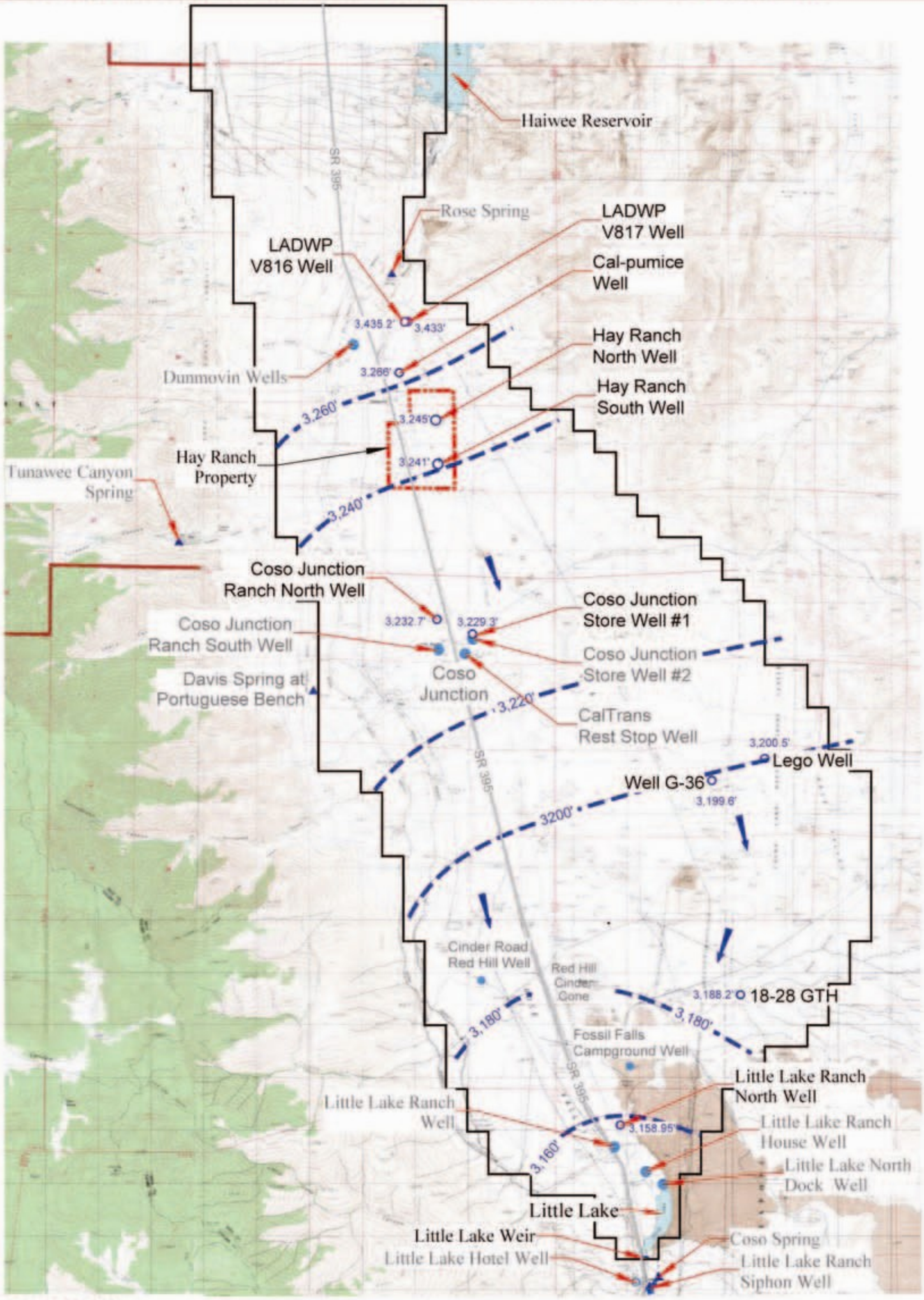
Well	Reference Point Elevation, ft MSL	Depth to Groundwater, ft	Groundwater Elevation, ft MSL
LADWP V816	3,515.35	80.15	3,435.20
LADWP V817	3,511.86	78.86	3,433.00
Cal-Pumice	3,506.38	240.38	3,266.00
Hay Ranch North	3,436.78	191.78	3,245.00
Hay Ranch South	3,420.25	179.35	3,240.90
Coso Junction Store #1	3,372.10	142.80	3,229.30
Coso Ranch North	3,402.72	170.02	3,232.70
G-36	3,379.85	180.25	3,199.60
Lego	3,422.81	222.31	3,200.50
18-28 GTH	3,362.62	174.42	3,188.20
Little Lake Ranch North	3,199.15	40.20	3,158.95
NOTE: Elevation survey to NGVD 1929 by Triad/Holme Associates (2007).			

Long term groundwater level monitoring data collected by COC beginning in September 2001 are tabulated in Appendix C2, Table C2-2. Long term monitoring well locations are shown on Figure 3.2-5. Groundwater elevation hydrographs developed from the monitoring data presented in Appendix C2 are shown on Figure 3.2-4.

Long term groundwater level monitoring conducted by COC indicates that groundwater levels have generally risen 1 to 2 feet throughout Rose Valley over the last 5 years (see Figure 3.2-4). This is most likely a response to increased precipitation recharge in the mountains in the last few years. There was no significant change in groundwater extraction in Rose Valley or identified groundwater recharge other than precipitation infiltration at higher elevations. An approximately 1 foot rise in water level was observed in the Cal-Pumice well north of the Hay Ranch property,1.5 foot rises were observed in Lego and G-36 wells on Navy property 7 miles southeast of Hay Ranch, and 2 foot rises were observed in the Hay Ranch wells.

Groundwater elevations in wells at the northern end of Rose Valley may be influenced by groundwater conditions outside Rose Valley (i.e., by variations in groundwater inflow from Owens Valley or variations in seepage rates from the Haiwee Reservoirs). Groundwater levels in the LADWP wells (V816 and V817) fell from 2002 to mid-2005, rose from mid-2005 until the spring of 2007, and subsequently began falling again. Groundwater levels in the LADWP wells were more variable than in any other wells in the valley. The groundwater levels in the LADWP wells are approximately 170 feet higher than groundwater levels in the closest monitored well, Cal-Pumice, suggesting a surface water flow component or input from a groundwater basin at a different groundwater elevation potential (i.e., Owens Valley). A comparison of water level data tabulated for the Haiwee South Reservoir (LADWP 2008), 2 miles north of the LADWP wells, to groundwater levels in the LADWP wells indicated no apparent correlation between water levels in the reservoir and groundwater levels between November and December 2007. No groundwater level monitoring data were identified for wells located at the southern end of Owens Valley near the Haiwee Reservoir to evaluate inflow from this source.

Figure 3.2-5: Study Area Map and Groundwater Elevation Contour Map - November 2007



SOURCE: Geologica 2008

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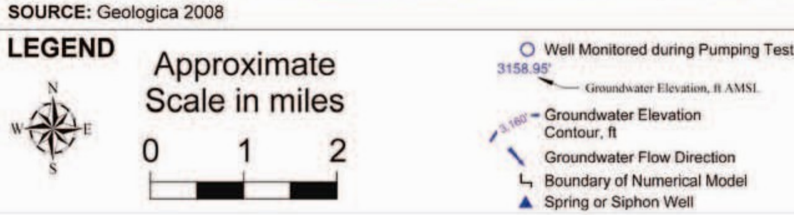

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Aquifer Properties

The transmissivity (ability to transmit water through the entire thickness of aquifer) of the upper portion of the alluvial deposits in Rose Valley was previously estimated to range from 9,000 to 69,800 gallons per day/foot (gpd/ft) or 1,200 to 9,330 ft^2/day, based on data presented in the hydrology technical report prepared as part of the BLM Coso Geothermal Leasing EIS (Rockwell International 1980). Based on 24-hour pumping tests conducted in the Hay Ranch wells, GeoTrans (2003) concluded that the transmissivity of the Rose Valley aquifer near Hay Ranch was approximately 10,000 ft^2/day and estimated that the hydraulic conductivity (transmissivity divided by the aquifer thickness) was approximately 20 ft/day. GeoTrans concluded that they had insufficient data to estimate aquifer storage properties.

Based on the long-term pumping test conducted in the Hay Ranch south well and monitoring results, the best estimate of the transmissivity and horizontal hydraulic conductivity of the aquifer are approximately 14,750 ft^2/day and 24 ft/day, respectively (see Appendix C1). Vertical hydraulic conductivity was estimated to be 0.01 ft/day and the aquifer storage coefficient was estimated to be 0.001 in the recent alluvial deposits.

Groundwater Flow Components and Water Budget

The data available indicate that the Rose Valley groundwater system is mainly recharged by mountain front recharge derived from precipitation and snowmelt that falls at higher elevations in the Sierra Nevada Front Range. Some precipitation recharge likely occurs from the Coso Range on the eastern side of the valley but was conservatively neglected for the modeling effort described in Appendix C2. Based on proportions of chloride in groundwater in southeastern Rose Valley compared to groundwater in the Coso basin to the east, as much as 250 acre-ft/yr of groundwater may enter southeastern Rose Valley as groundwater inflow from the Coso Basin. This flow was conservatively neglected in modeling analysis. Leakage from the LADPW aqueducts that traverse Rose Valley was assumed to be a negligible component of total groundwater inflow to the basin.

The principal groundwater outflow components currently consist of groundwater underflow and discharges to surface water in the Indian Wells Valley to the south and evapotranspiration from Little Lake and wetland vegetation on the Little Lake Ranch property. Essentially all of the precipitation falling on Rose Valley is assumed to be lost to evapotranspiration based on data from nearby Owens Valley (Danskin 1998); however, because the groundwater table is located 40 or more feet below ground surface over all but the southern tip of the valley, evapotranspiration does not factor into the groundwater budget except on the Little Lake Ranch property. Inflow and outflow components of the groundwater budget for Rose Valley are discussed in more detail below.

Rose Valley Groundwater Inflow Components. Principal inflow components to Rose Valley consist of Sierran mountain front recharge, groundwater inflow from Owens Valley to the north, and/or outseepage from Haiwee Reservoir.

Mountain Front Recharge. Precipitation in the Sierra Nevada range west of Rose Valley is the principal source of groundwater recharge to the Rose Valley basin. Due to the rain shadow effect caused by the Sierra Nevada Range, the precipitation rate in the Coso Range on the east side of Rose Valley is low. It was conservatively assumed that evapotranspiration exceeded potential precipitation recharge throughout Rose Valley and the Coso Range, yielding no recharge in Rose Valley. Methodologies to directly measure mountain front recharge are poorly defined; typically groundwater recharge from precipitation is estimated as a percentage of total recharge.

Brown and Caldwell (2006) concluded that precipitation rates in the Rose Valley area range from about 6 inches per year (in/yr) on the valley floor to up to 20 in/yr at the crest of the Sierra Nevada range, and that only precipitation falling at elevations above 4,500 ft results in groundwater recharge. Brown and Caldwell (2006) estimated that the total precipitation volume that could potentially recharge the Rose Valley groundwater basin was approximately 42,000 acre-ft/yr. For the purposes of the initial evaluation of potential impacts of groundwater development at Hay Ranch, they further assumed that only 10% (4,200 acre-feet/year) of the potential mountain front precipitation recharge actually reaches Rose Valley. The mountain front precipitation recharge rate as assumed for the Brown and Caldwell groundwater flow model yielded reasonable calibration results in the steady state model; therefore, a recharge rate of 4,200 acre-ft/yr was also used in the revised numerical model developed for this EIR. The recharge was assigned to selected nodes on the western boundary of the model, primarily along the trace of ephemeral streams (see Appendix C2).

Groundwater Inflow/Seepage from the North. Weiss (1979) estimated seepage losses from the Haiwee Reservoir to be on the order of 600 acre-ft/yr. Previous investigations (Bauer 2002; Brown and Caldwell 2006) and the review of groundwater elevation contour patterns in the north end of Rose Valley indicate that groundwater inflow from southern Owens Valley and/or seepage losses from the south Haiwee Reservoir recharge the Rose Valley groundwater basin at the north end of the valley. Using a steady-state numerical groundwater flow model of the Rose Valley groundwater basin, Brown and Caldwell (2006) estimated the groundwater influx from the north to be approximately 788 acre-ft/yr, which is similar to the estimate in Weiss (1979). Recalibration of the numerical groundwater flow model for this study indicated a slightly higher groundwater inflow rate from the north (Owens Valley/Haiwee Reservoir) of 898 acre-ft/yr.

Groundwater Outflow Components. Principal groundwater outflow components from Rose Valley consist of discharge to Indian Wells Valley in the Little Lake area and an area in the southeastern part of the valley, east of Red Hill, and evapotranspiration in the Little Lake area. Limited groundwater extraction was identified in Rose Valley.

Groundwater Discharge from Southeastern Rose Valley. Brown and Caldwell (2006) estimated that approximately 2,050 acre-ft/yr of groundwater discharges from Rose Valley in the southeastern part of the valley (southeast of Navy well 18-28) as underflow to Indian Wells Valley. Williams (2004) concluded that existing estimates of recharge to the Indian Wells Valley significantly underestimated interbasin transfers and referenced an estimate of groundwater underflow from Rose Valley to Indian Wells Valley of 10,000 acre-ft/yr developed by Thompson (1929). Recalibration of the numerical groundwater flow model for Rose Valley indicated an underflow rate from Rose Valley to Indian Wells Valley in this area of 850 acre-ft/yr. This rate is less than half the value of 2,050 acre-ft/yr assigned to this term in the earlier Brown and Caldwell (2006) numerical modeling analysis. This difference is discussed in the model calibration section of Appendix C2.

Groundwater Discharge at Little Lake. Water is removed from the Rose Valley aquifer by several processes. These include:

- Evaporation from the surface of Little Lake and surrounding ponds
- Transpiration from plants on the Little Lake property
- Groundwater discharge to Indian Wells Valley

Bauer (2002) estimated that evaporation from the Little Lake water surface consumes approximately 500 acre-ft/yr based on a lake surface area of 75 acres and a potential evaporation rate of 80 inches/yr. As discussed in Section 3.4, plant communities and habitat identified on the Little Lake Ranch property were described as alkali desert (saltbush scrub), palustrine (pond) and lacustrine (lake) wetlands, and riparian (creek) habitat. Beginning in 2000, Little Lake Ranch, Inc., conducted various projects intended to create 90 acres of open waters, 10 acres of palustrine emergent wetlands, about 6 acres of palustrine/riparian habitat (1.6 mile long creek corridor), an additional 220 acres of wetland and upland habitat, and 1 acre of wetland and associated upland habitat (ULLR 2000).

As a result of shallow groundwater in this area and the information presented above, it is estimated that about 300 acres of the 1,200 acre Little Lake Ranch property hosts various species of plants. Studies summarized in the USGS Water-Supply Paper for Owens Valley (Danskin 1998) concluded that wetland plant species in the desert climate prevalent in Owens (and Rose Valley) transpire between 20 and 36 inches/yr. Using an average evapotranspiration value of 28 inches/yr over the 300 acres yields an estimated 700 acre-ft/yr for transpiration processes (in addition to 500 acre-ft/yr assumed for surface water evaporation from Little Lake). The estimation of evapotranspiration is likely an overestimate because not all 300 acres includes plants with wetland evapotranspiration rates.

The combined total of measured lake, spring, and groundwater discharges and estimated evapotranspiration losses in the Little Lake Ranch area was approximately 4,200 acre-ft/yr. All of the groundwater discharged through the entire saturated thickness of aquifer in the Little Lake area that is not evaporated or transpired by plants infiltrates back into the ground on the property (approximately 3,000 acre-ft/yr) and continues as groundwater underflow to Indian Wells Valley. This is slightly lower than the value of 3,300 acre-ft/yr estimated by Williams (2004) for interbasin transfer from Rose Valley to Indian Wells Valley, but does not include the groundwater underflow component from the southeastern Rose Valley discussed in the previous section.

Existing Extraction Wells. Groundwater production from wells in Rose Valley is currently approximated at 50 acre-ft/yr. No significant agricultural irrigation has occurred in the valley since the Hay Ranch alfalfa growing operation ceased. As many as 30 domestic wells are believed to extract relatively small quantities of groundwater for domestic uses and small scale irrigation in the Dunmovin area. This pumpage is not represented in the groundwater flow model because it is believed to amount to less than 10 acre-ft/yr. The LADWP, Cal-Pumice, and Hay Ranch wells are not being pumped and are not known to have been used in the last five years. The Coso Ranch south well, southern Coso Junction store well (Coso Junction #2), and the CalTrans well at Coso Junction are regularly used for businesses in the area. The Coso Ranch north well and northern Coso Junction store well (Coso Junction #1) are not being used at present. Cal-Pumice reportedly takes 5 to 10 truckloads (15,000-30,000 gallons) of water a day during the week from the Coso Ranch south well, which was set in the model as a continuous withdrawal of 17 acre-ft/yr (or roughly 10 gpm). The Coso Junction Store well supplies the general store and COC offices in Coso Junction and was also represented as a continuous withdrawal of 17 acre-ft/yr. Extraction from the CalTrans well was assumed to be negligible. At the southern end of Rose Valley, the Red Hill well on Cinder Road is believed to be used for supplying water for the cinder pit at Red Hill. The volume of water needed for this operation is estimated to be 2 to 4 truckloads (approximately 5,000 to 10,000 gallons) per day, based on anecdotal information. Wells on the Navy property in Rose Valley including the Lego well, well G-36, and well 18-28, are not being pumped. Water wells on the Little Lake Ranch property were discussed in the previous section.

Groundwater Budget

The groundwater elevation monitoring data shows a general rise in water levels that suggests that groundwater inflows (sources) have equaled or slightly exceeded groundwater outflows from the Rose Valley groundwater basin in the past five years. Assuming that groundwater inflows equal outflows (i.e., steady state conditions prevail) is a conservative approach that underestimates the amount of available groundwater. The resulting Rose Valley groundwater budget was evaluated under this conservative assumption, using a numerical model (refer to Appendix C2) as shown in Table 3.2-3.

Table 3.2-3: Rose Valley Conceptual Groundwater Budget

Budget Components	2006 Model		2007 Model	
	Flow Rate, acre-ft/yr	Simulation Package used in Model	Flow Rate, acre-ft/yr	Simulation Package used in Model
Groundwater Inflow				
Mountain Front Recharge from west	4,191	Well	4,194	Well
Groundwater Underflow from the North	788	Constant Head	898	Constant Head
Total Inflow	**4,979**		**5,092**	
Groundwater Outflow				
Existing extraction wells	0	--	50	Well
Groundwater underflow to Indian Wells Valley exiting from southeastern Rose Valley	2,050	General Head	842	General Head
Evaporation from Little Lake and Evapotranspiration from adjacent Palustrine wetland plants	500	Evapotranspiration	700	Evapotranspiration
Phreatophyte plant transpiration on Little Lake Ranch property south of Little Lake (outside model grid)	0	--	500	--
Groundwater Discharge through Little Lake Gap to Indian Wells Valley	2,429	Drain	3,000	General Head
Total Outflow	**4,979**		**5,092**	

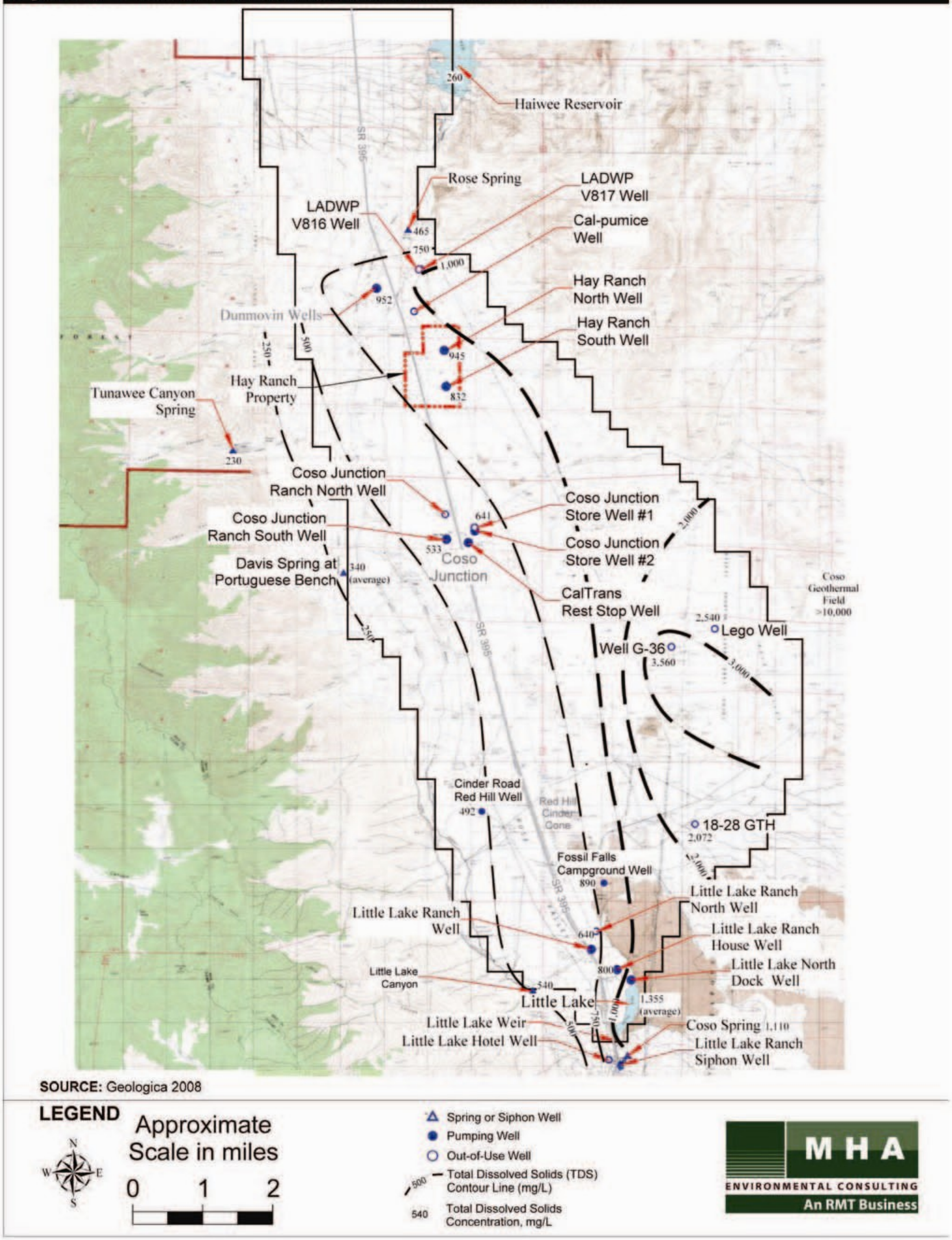
*Conceptual budget, simulated budget components were adjusted during model calibration process.

Water Quality

The chemistry of waters found in Rose Valley watershed varies widely reflecting the multiple types of waters within the hydrological system of semi-arid western US environments. The water chemistries are influenced by the interaction between groundwater and rock along the hydrological flow paths with the addition of a geothermal brine component. Recharge waters from drainage of the mountains surrounding Rose Valley have lower dissolved solids than the valley's groundwater, which typically is higher in dissolved solids reflecting longer transit times and a greater degree of water-rock interaction. Surface waters can be even higher in dissolved solids where it is impacted by evaporation (Guler 2002). Outflow of saline geothermal brines from the Coso geothermal system to the east may also provide a component of flow to the Rose Valley hydrological system.

Total dissolved solids (TDS) range from very low to a few hundred milligrams per liter (mg/L) in surface streams draining the Sierras to the west or in springs of the Coso-Argus Range to the east to several thousand mg/L in geothermal brines in the Coso Geothermal Wellfield to the east. Groundwater in the northern Rose Valley near Hay Ranch is characterized by TDS between 800 and 900 mg/L whereas groundwater in the southern Rose Valley is characterized by TDS from 500 to 700 mg/L. At Little Lake the water is slightly brackish with TDS from 1,500-2,500 mg/L. The TDS levels throughout the Rose Valley are shown in Figure 3.2-6.

Figure 3.2-6: Inferred Total Dissolved Solids Concentration Distribution



Chemical analysis of water samples collected in the Rose Valley and vicinity indicates that there are several distinct water types (refer to Appendix C4). Sierran waters (and minor amounts of water from the Coso Range) recharge the area (Guler 2002 and Williams 2004). There also appears to be a small inflow of subterranean discharge from the Coso Geothermal System. The chemistry and isotopic signatures of the other types of water suggest that the Rose Valley hydrological system contains waters that have followed different and sometimes complex pathways from their mountain sources to points of discharge.

Guler (2002) and Williams (2004) compiled an extensive database of chemical analyses of waters within the area to evaluate and characterize water quality. They grouped the waters within the area into several water types:

- Sierran: springs and streams that drain the Sierras; calcium (Ca)- (sodium, Na)-bicarbonate (HCO_3); average TDS≈200 mg/L
- Indian Wells Rose Valley: springs, streams and shallow groundwater in basins along the eastern side of the Sierra; Na-Ca-HCO_3-(sulfate, SO_4); average TDS≈700 mg/L
- Coso-Argus Group: surface and spring samples from the Coso and Argus Ranges; Ca-HCO_3 - average TDS≈500 mg/L
- Little Lake Group: Samples from Little Lake and surrounding springs; Na-(Mg)-HCO_3 -Cl; average TDS≈1200 mg/L
- Geothermal Brine: from deep (500-3000m Coso geothermal reservoir); Na-Cl; TDS≈10,000 mg/L

A review of chemical and isotopic analysis of water samples from Rose Valley suggests that Sierran, Indian Wells-Rose Valley (IWRV), Little Lake (LL), and possibly a component of geothermal brine types are present in Rose Valley groundwater. Within the IWRV type, Portuguese Bench, Coso Junction, and Hay Ranch waters are clearly distinguished from each other and from Little Lake and geothermal waters, particularly in the conservative element of chloride. Little Lake waters, represented by the LL Ranch House Well, LL (an average of surface waters), and the Coso Spring are clearly distinguished from other Rose Valley groundwaters by higher concentrations of all constituents except Ca and Mg. The only exception is the geothermal-influenced Lego and 18-28GTH wells. Williams (2004) suggests that elevated Na relative to Ca, Mg, and Cl, as well as boron (B) and lithium (Li), indicate a geothermal component in Little Lake waters. However, the elevated chloride in Little Lake waters may also be a result of evaporation (concentration) of waters from nearby Sierran recharge from the west (as represented by Little Lake Canyon Spring) combined with groundwater flow down the valley (represented by Little Lake north well water).

Chemical Analyses and Water Types

Hay Ranch groundwater appears to be a more concentrated version of Haiwee Reservoir water. The dominance of sulfate in waters in the northern part of Rose Valley (Hay Ranch and Dunmovin) distinguishes these waters from the rest of the valley. Although the Hay Ranch wells were drilled deeper than many of the other wells in the valley, the Dunmovin well is not, so depth alone probably does not produce the difference in water chemistry. Concentration of these waters by evaporation would not produce the chemistry of the Little Lake waters.

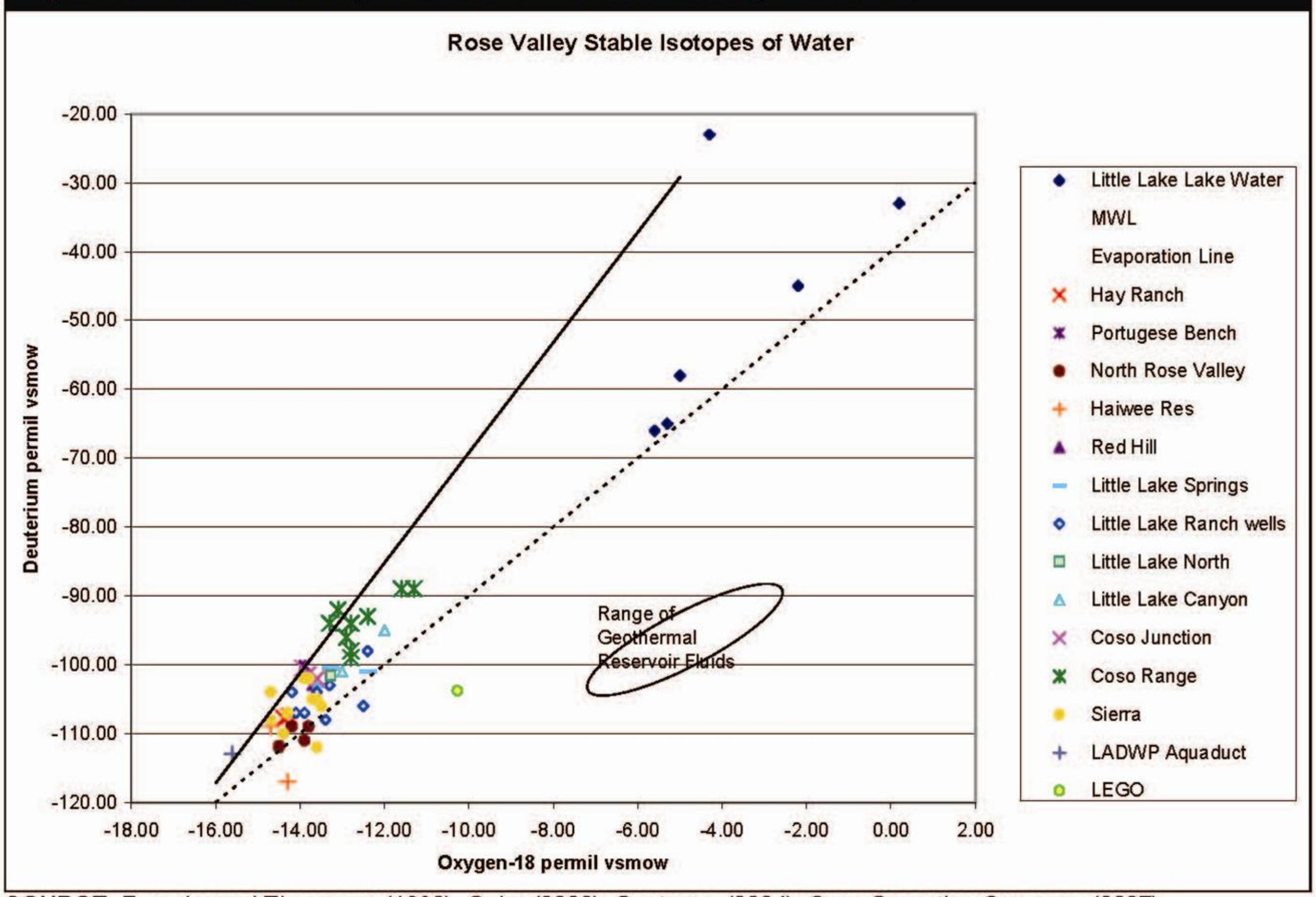
Despite the different chemistries of waters at discharge points within Rose Valley watershed most waters appear to generally have the same origin. Similar boron/chloride ratios (the ratio of two relatively conservative elements) support similar origins. Boron/chloride ratios within the Hay Ranch watershed are similar to water from the Sierras and to the Coso geothermal waters suggesting that although various processes change the absolute concentrations of these conservative elements, the source of the water is likely precipitation in the Sierra and Coso Ranges.

Isotope Data

Stable water isotope (oxygen-18 and deuterium) signatures are commonly used to evaluate the origins of waters. Isotope concentrations of waters from within the Rose Valley and its watershed reflect variable sources as well as evaporation. Evaporation enriches waters in the heavier stable isotopes making the waters less isotopically negative. At first glance, the stable isotopes of Little Lake waters appear different from all other waters reflecting the evaporation of these shallow lakes (Figure 3.2.7).

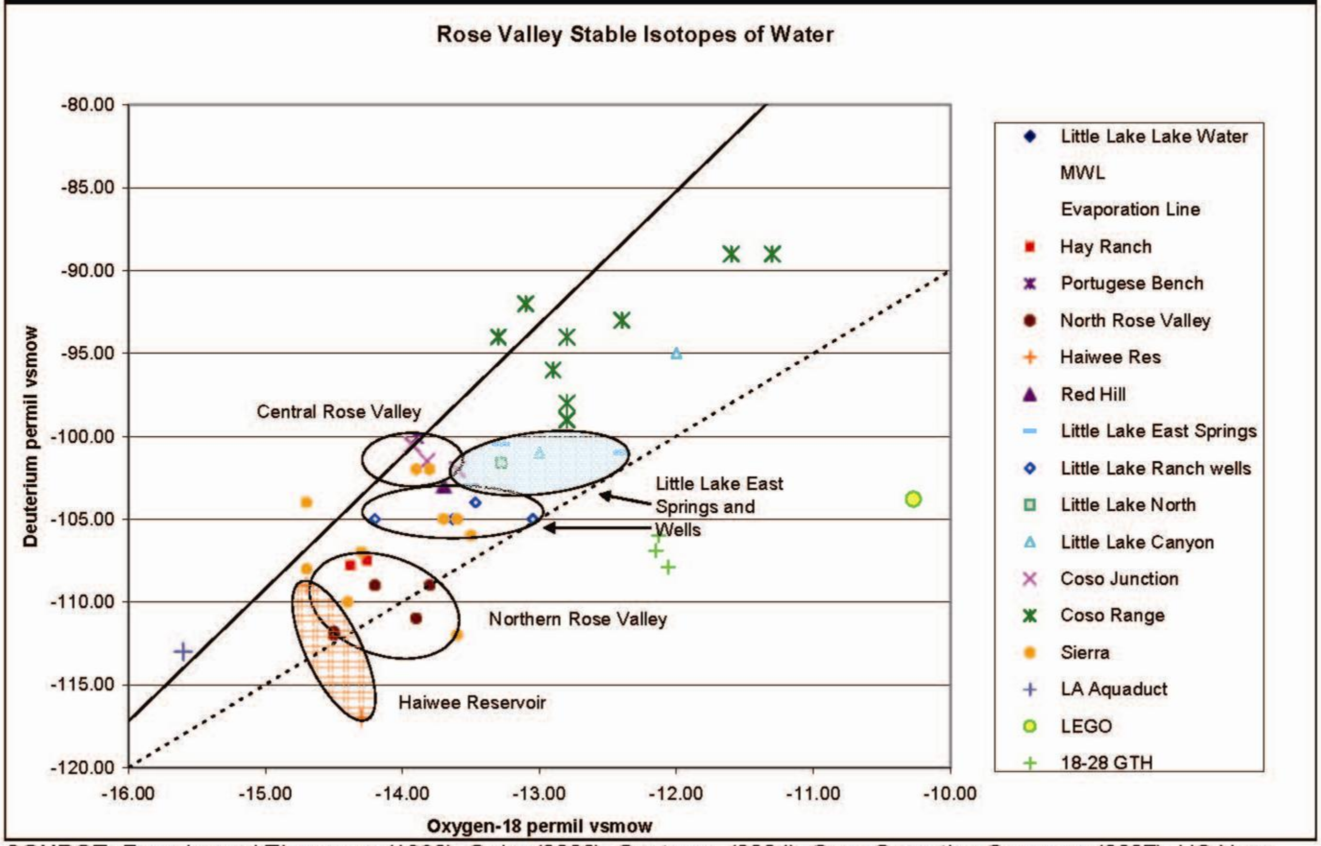
When focusing on groundwater represented by well and spring waters (minimizing the effect of evaporation), stable isotopes also suggest differences in sources of groundwaters from the northern to the southern end of the valley. These differences may in part reflect differences in recharge from the Sierra, which is isotopically lighter (more negative) to the north as represented by the LADWP Aqueduct water and Haiwee Reservoir and isotopically heavier (less negative) in the south. The stable isotopic signature of the northern part of the Valley (including Hay Ranch waters) is similar to the Haiwee Reservoir and the highest or more northerly Sierras. Portuguese Bench and Coso Junction waters appear to be similar to each other and isotopically more like the Sierras farther south than Haiwee and more directly west of Rose Valley (Figure 3.2-8). Thus, the isotopic signature of Rose Valley groundwaters suggest that there is recharge from the Sierras all along the north-south axis of the valley, with different isotopic signatures, in addition to some valley underflow from north to south.

Figure 3.2-7: Stable Isotopes of Waters from Rose Valley and Vicinity



SOURCE: Fournier and Thompson (1980), Guler (2002), Geotrans, (2004), Coso Operating Company (2007).

Figure 3.2-8: Oxygen-18 versus Deuterium for Waters from Rose Valley and the Surrounding Areas



SOURCE: Fournier and Thompson (1980), Guler (2002), Geotrans, (2004), Coso Operating Company (2007), US Navy GPO (2007 and 2008).

The isotopic signature of groundwater in wells or springs downgradient from Little Lake (i.e., Little Lake East Spring, also known as Coso Spring, and Little Lake Ranch Wells) is probably affected by evaporation of the lake water. Little Lake North Well probably represents unevaporated recharge to the Lake. The source waters for Little Lake appear to be either:

1) From the Sierran source area of Portuguese Bench springs with a longer subsurface pathway (which increases oxygen-18 by water-rock interaction but not deuterium), or
2) Predominantly Portugese Bench type Sierra water and a small amount of geothermal water (or geothermal mixed water), or
3) Predominantly Portuguese Bench type Sierra water and a small amount of Rose Valley underflow from the north.

If the major source of Little Lake water was directly from the Hay Ranch area, significant evaporation would have to occur at Little Lake to change the water chemistry. Groundwater flow within the Rose Valley would have a major diversion around Coso Junction, or alternatively, Little Lake water is influenced from the geothermal waters to the east. In either case, water isotopes suggest the water sources for the Little Lake area are predominantly from the local Sierran watershed to the west and are distinct from the Northern Rose Valley water chemistries, potentially indicating more recharge from the west than from the north. Slight displacement towards a lighter isotopic signature from the area around Portuguese Bench may reflect a slight influence of groundwater underflow from north to south through Rose Valley.

Water Potability

Drinking water quality (potability) of waters within the Rose Valley ranges from excellent to marginal. Available data (Coso 2007; Geotrans 2004) indicate that Hay Ranch waters exceed primary drinking water standards (EPA 2003) for arsenic, nitrate and nitrite Secondary drinking water standards are primarily related to aesthetics and taste. Several waters exceed the secondary drinking water standard levels for TDS and sulfate (Coso 2007; Williams, 2004; Fournier and Thompson 1980). Recent analysis of water samples from the Hay Ranch wells indicates the water does not meet secondary drinking water standards for TDS, sulfate, iron and manganese (see Table 3.2.4 from Geotrans 2004).

Geothermal System and Surface Manifestations

The local hydrological setting of the Hay Ranch area includes a high temperature (200-328^{o}C) hydrothermal system and associated surface manifestations located within the Coso Range between Rose Valley and Coso Wash.

The Coso hydrothermal system supports the Coso geothermal field, which has been producing geothermal fluids for electrical power generation since late 1987. There are several surface manifestations of the system known as Coso Hot Springs. Approximately 14,000,000 lbs/hour of hot geothermal steam and brine are produced from approximately 80 to 90 deep (3,300 to 10,000 feet bgs,) wells (Adams et al. 2000; Monastero 2002) for power generation. This fluid is flashed to steam and the steam powers the turbine while the unflashed portion of the brine is injected into the subsurface. The injection rate is approximately 50% of the production rate constituting in a net loss of fluid in the reservoir which, over 20 years of production, has resulted in a decline in pressure and development of a vapor-dominated zone (ITSI 2006; Adams 2004). Initially, fluid was produced from a predominantly liquid-dominated reservoir at an average total enthalpy of just above 400 Btu/lb. Now the average enthalpy is closer to 800 Btu/lb, suggesting that a significant portion of the produced fluid is from a vapor-dominated zone of the reservoir.

The project includes transferring water to the Coso geothermal field for injection. The Coso geothermal field project has been permitted through 2031.The geothermal system is part of the hydrogeologic setting of the project and, therefore, a brief description follows.

Geothermal System

The Coso hydrothermal system has been in existence for over 300,000 years. Temperature and fluid chemical variations over its existence (pre-production) may reflect variations in heat supply and recharge (Adams et al. 2000). Coso is located in a tectonically active area southwest of the Walker Lane, east of the Sierra Nevada, and north of the Garlock fault zone (Montasero 2000, Unruh et al., 2002). The system appears to be heated by shallow (approximately 4 km; Wicks et al. 2001; 4-5 km, Lees 2002) magma associated with the brittle ductile transition zone. Volcanic rocks related to this magma date from 4 million to 40,000 years (Duffield et al. 1980).

The source of the geothermal fluids appear to be meteoric waters from the Sierra Nevada (Fournier and Thompson 1980) or the Coso Range (Williams and McKibben 1990) or both (Williams 2004), with contributions of volatiles and other fluids from magmatic sources. However, there does not appear to be any current natural recharge to the system. Climate has changed from the last glacial periods to the currently dry and arid conditions. Over this same period and before development, the low-salinity non-thermal groundwater system that overlaid and recharged earlier phases of the geothermal system disappeared (Adams et al. 2000).

Before development, the geothermal system appears to have been a sodium chloride liquid-dominated system. The Coso geothermal field appears to have been developed in phases. Development involves production of hot brine from deep (4,000-9,000 feet) wells, boiling and

Table 3.2-4: Hay Ranch Drinking Water Quality with Primary and Secondary Drinking Water Standards

HAY RANCH NORTH AND SOUTH WELL GROUNDWATER ANALYTICAL RESULTS for Drinking Water Quality

ANALYTE	Drinking Water Standard[1]	MCL[2] or Secondary Level[2] (mg/l)	South Well 09/10/2003 Result[3] (mg/l)	South Well 09/11/2003 Result[3] (mg/l)	South Well 12/03/2007 Result (mg/l)[4]	North Well 09/13/2003 Result[3] (mg/l)	North Well 09/14/2003 Result[3] (mg/l)	Coso Junction Office Well[4] 01/30/03 Result[3] (mg/l)
General Minerals								
Alkalinity, Total			330	320		260	250	
Bicarbonate (as $CaCO_3$)			330	320		260	250	326
Carbonate (as $CaCO_3$)			ND	ND		ND	ND	
Hydroxide (as $CaCO_3$)			ND	ND		ND	ND	
Chloride	Secondary	250	74.1	75.7	73	72	79	33.7
Conductivity (umho/cm)			1320	1300		1360	1370	
Cyanide	Primary (CA)	0.15			<0.1			
Fluoride	Primary	2.0	0.22	0.20	0.31	0.15	0.20	0.53
Hardness (Ca, Mg-$CaCO_3$)			465	455		430	430	
Nitrate	Primary	10	2.15	2.60	**12**	1.44	2.05	6.01
Nitrite	Primary	1			**2.7**			
Sulfate	Secondary	250	**257**	**251**	**260**	**336**	**329**	97.3
Total Dissolved Solids (TDS)	Secondary	500	**850**	**844**	**850**	**910**	**945**	**634**
Other								
pH (pH units)	Secondary	6.5-8.5	7.12	7.28	7.61	7.43	7.48	6.53
Color	Secondary	15 units			<3.0			
ODOR	Secondary	3 TON			<1.0			
MBAS	Secondary	0.5			<0.05			
Asbstos	Primary	7 MFL			<0.2 MFL			
Metals								
Aluminium	Primary (CA)	1			0.054			
Antimony	Primary	0.006	ND	ND	<0.002	ND	ND	
Arsenic	Primary	0.010	ND	ND	**0.016**	ND	ND	0.0034
Barium	Primary	2	0.058	0.042	<0.1	0.036	0.033	
Beryllium	Primary	0.004	ND	ND	<0.001	ND	ND	
Cadmium	Primary	0.005	ND	ND	<0.001	ND	ND	
Calcium			114	113		97.6	96.3	73.7
Chromium	Primary	0.1	ND	ND	<0.01	0.012	ND	
Cobalt			ND	ND		ND	ND	
Copper	Primary	1.3	ND	ND	<0.05	ND	ND	
Flouride	Primary	0.002						
Iron	Secondary	0.3	**7.01**	0.27	<0.1	**1.35**	0.114	
Lead	Primary	0.005	ND	ND	<0.002	ND	ND	
Magnesium			39.8	37.7		37.6	36.0	36.6
Manganese	Secondary	0.05	**0.449**	0.047	<0.02	**0.100**	0.012	
Mercury	Primary	0.002	ND	ND	<0.0002	ND	ND	
Molybdenum			ND	ND		ND	ND	
Nickel			ND	ND		ND	ND	
Potassium			11.8	11.8		8.67[3]	9.38	6.91
Selenium	Primary	0.05	ND	ND	0.003	ND	ND	
Silver	Secondary	0.10	ND	ND	<0.01	ND	ND	
Sodium			111	111		136	133	50.3
Thallium	Primary	0.0005	ND	ND	<0.001	ND	ND	
Vanadium			ND	ND		ND	ND	
Zinc	Secondary	5	0.032	0.022	<0.05	0.033	0.036	

1 - Primary and Seconday Drinking Water Standards as defined by the US EPA, June, 2003 inless noted with CA for California Standards.

2 - MCL = Maximum Contaminant Levels are legally enforceable standards that apply to public water systems; Secondary Levels are suggested but not enforceable guidelines for drinking water.

3 - Results are bold for those that exceed the MCL or Secondary Level for the respective analyte.

4 - Coso Junction office well results received from Paul Spielman, Caithness Energy.

This table is compiled from Geotrans, 2004 with addition from Coso in 2007.

South Well sampled September 10-11, 2003 and December 3, 2007; North Well sampled September 13-14, 2003.

SOURCE: GeoTrans 2004, COC 2007, EPA 2003 (standards) separation of resulting steam and waste brine, and reinjection of spent brine and steam condensate. The reservoir now appears to be compartmentalized into at least three weakly connected areas with the hottest and deepest in the south. Subsequent production-induced pressure declines have produced vapor-dominated portions of the field today, causing some production wells to produce only steam.

Surface Manifestations

The geothermal surface manifestations at Coso are primarily located along the Coso Wash Fault northeast of the Coso geothermal field. Coso Hot Springs lie just east of the fault and Devils Kitchen lies further west. These surface manifestations appear to be primarily related to steam discharge from the geothermal system along fractures, but some features discharge fluids with some portion of geothermal brine. All features are characterized by variable discharge rates or water levels and temperatures (Geologica 2007).

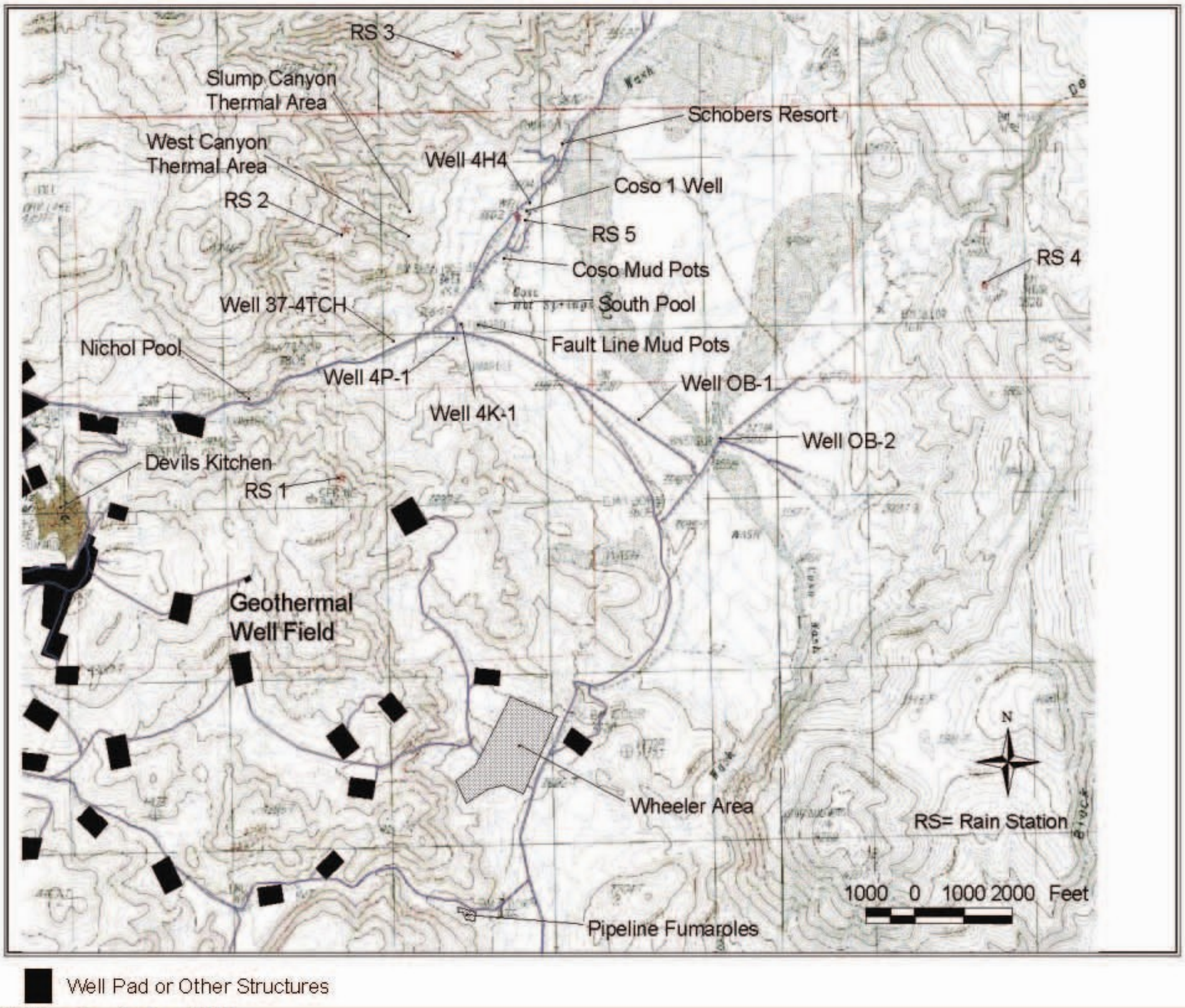
The Navy monitors surface manifestations to comply with a 1979 Memorandum of Agreement (MOA) between the CLNAWS, the State Historic Preservation Office (SHPO), and the Advisory Council on Historic Preservation (ACHP) and to document the physical and chemical conditions of the Coso Hot Spring Archeological District in order to “avoid or satisfactorily mitigate any adverse effects on significant historic or cultural property.” Baseline studies and continuous annual monitoring have been part of the Navy’s technical program since the Coso geothermal field was considered for leasing and development. Monitoring has established an accurate and reliable record of the physical conditions of surface manifestations. The Coso Hot Springs monitoring program includes the collection of:

- Local meteorological data
- Measurements of fumaroles and mud pots
- Photographic documentation
- Water level measurements in selected water wells
- Chemical data from select fluid samples
- Steam flow measurements from selected monitoring points (see Figure 3.2-9).

South Pool (Figure 3.2-10a) and Devil’s Kitchen (Figure 3.2-10b) are prominent surface manifestations at Coso Hot Springs. The South Pool has been the principal focus of efforts to monitor surface manifestations. The other historically prominent feature is Devil’s Kitchen, which was dry for the second year since monitoring began during 2005-2006. Other consistently active areas, such as the Wheeler Area (Wheeler Mercury Prospect), the Slump Canyon thermal area, West Canyon thermal area, and Nichol Pool (Figure 3.2.10c), are variable in character and level of activity. For example, Pipeline Fumaroles (Figure 3.2.10d) became more active after the year 2000 but were dry in 2006. During the 2005-06 sampling season, increased activity was observed at the Fault Line Pool (near South Pool). Approximately 20 small fumaroles, approximately two inches high, were observed forming in November 2005.

Fluids in the Coso Hot Springs area are primarily steam, steam condensate, or steam-heated groundwater (which contains negligible amounts of chloride). Major cation (Figure 3.2-11) and anion concentrations in the surface manifestations reflect the type of fluid feeding the feature. Discharge of the sodium-chloride brine discovered in Coso Well #1 is limited to the east side of the Coso Wash Fault (Wheeler area, OB-1, and OB-2) and Nichol Pool (Figure 3.2.2e). The remainder of the features, including South Pool (Figure 3.2.10a), Devil’s Kitchen (Figure 3.2-10b) and Pipeline Fumarole (Figure 3.2-10d), are predominately low-pH sulfate calcium-magnesium fluids typical of

Figure 3.2-9: Coso Hot Springs Surface Manifestations and Monitoring Points



SOURCE: Geologica 2008

Figure 3.2-10a: South Pool

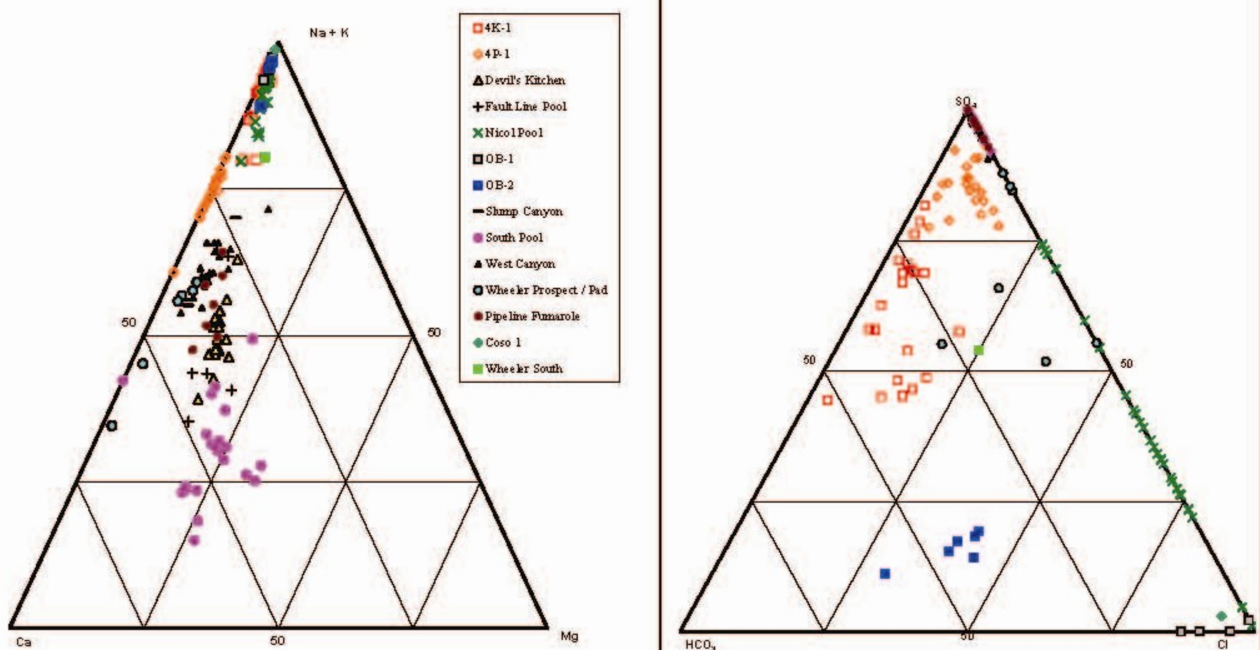
Figure 3.2-10b: Devil's Kitchen

Figure 3.2-10c: Nichol Pool

Figure 3.2-10d: Pipeline Fumarole

SOURCE: Geologica 2008

Figure: 3.2-11: Relative Proportions of Anions and Cations in Coso Surface Manifestations



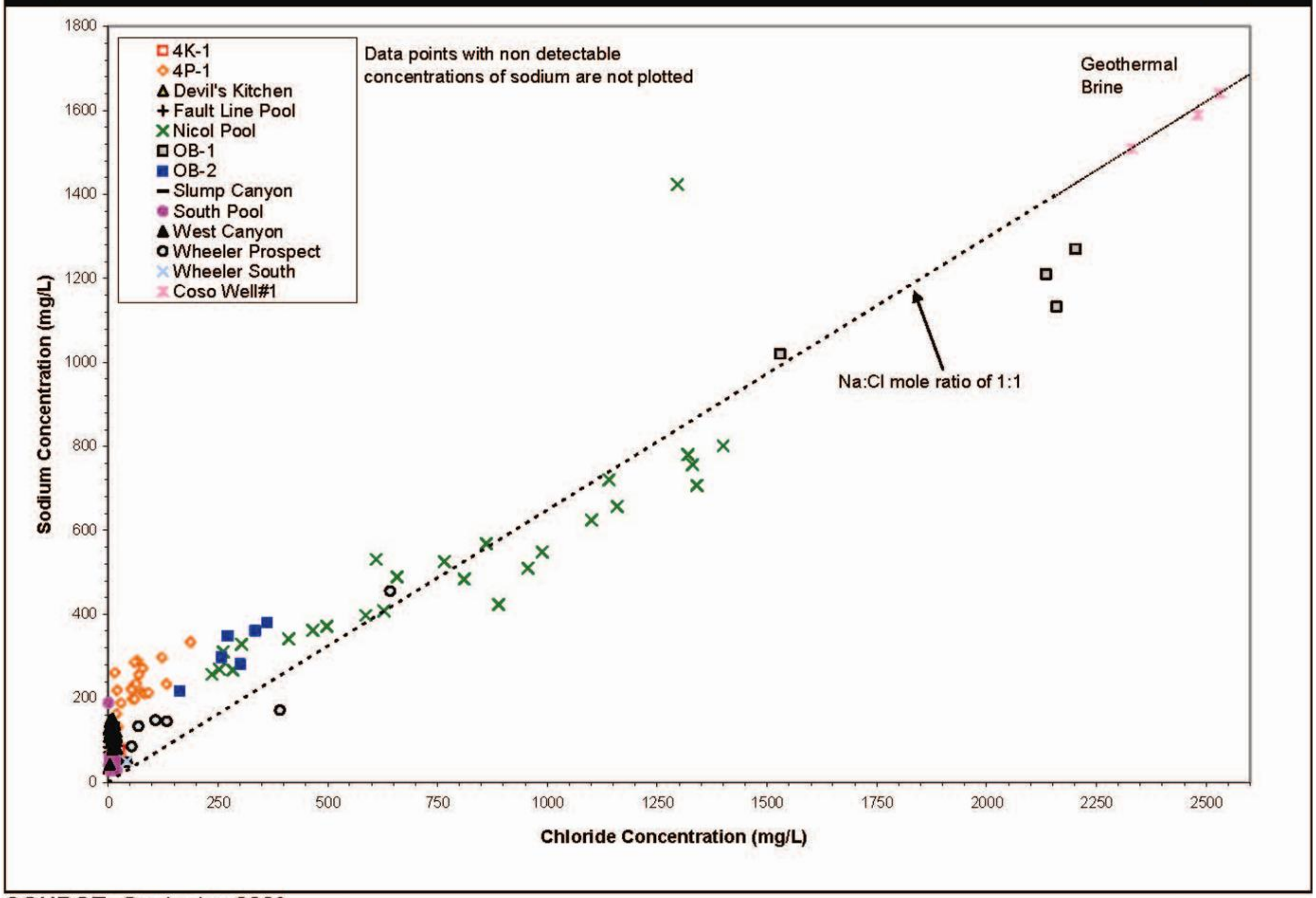
Relative proportions of cations in Coso surface manifestations: sodium+potassium (Na+K), magnesium (Mg), and calcium (Ca). Brine-dominated features cluster at the top (Na+K) of the triangle, steam-fed at the bottom (Ca-Mg).

Relative proportions of anions in Coso surface manifestations: sulfate (SO4), bicarbonate (HCO3), and chloride (Cl). Steam-fed features cluster at the top (SO4) of the triangle, brine-dominated at the bottom right (Cl), and groundwater at the left (HCO3).

steam-fed geothermal features such as fumaroles and mud pots. Concentrations of sodium and chloride (Figure 3.2-12) clearly distinguish between brine-influenced and steam-fed shallow wells and surface manifestations.

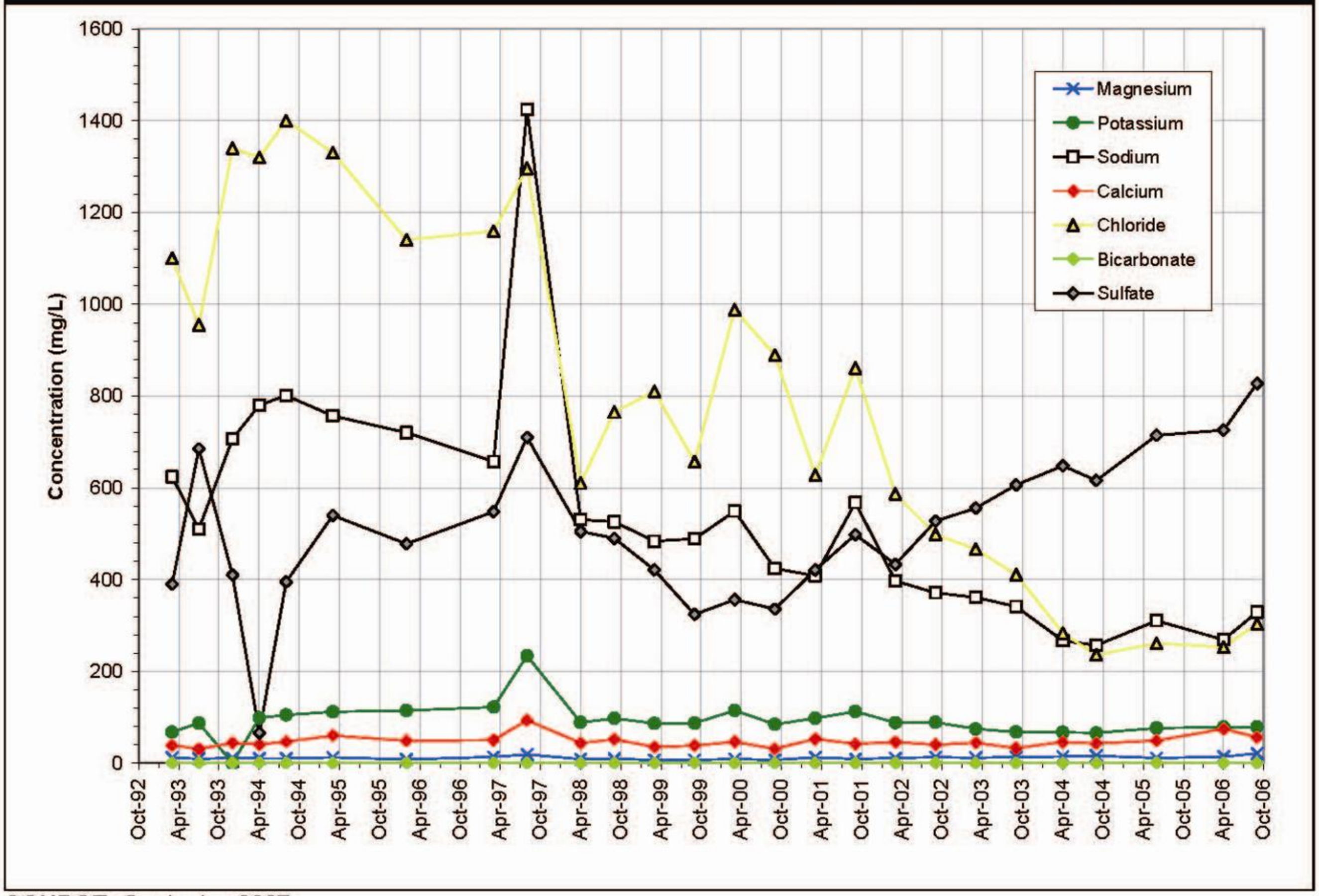
The Navy collects monitoring data at Coso Hot Springs on well temperatures, fluid chemistry and surface manifestations. The data documents temperature increases and expanded steam-related thermal activity in the shallow outflow of the Coso geothermal system. Two decades of systematic temperature surveys in shallow monitoring wells record the steady increase in temperatures in shallow aquifers beyond well established seasonal variations for surface manifestations and shallow wells. While the influence of brine relative to steam in discharge from Nichol Pool (Figure 3.2-13) and the Wheeler areas has recently declined, it appears to have increased since 2000 in Devils Kitchen. Increased temperatures, expanded thermal activity, and geochemical evidence of increasing steam influx have been relatively consistent since 1993; however, with the exception of seasonal and diurnal fluctuations, changes in chemistry, temperatures, water levels and steam flow rates are erratic and appear to have complex sources.

Figure 3.2-12: Sodium Chloride in Surface Manifestations and Shallow Wells at Coso Hot Springs



SOURCE: Geologica 2008

Figure 3.2-13: Variations in Chemistry of Nichol Pool



SOURCE: Geologica 2007

3.2.2 REGULATORY SETTING

Federal

Clean Water Act

The Clean Water Act (CWA) has regulated the discharge of pollutants to waters of the United States from any point source since enacted in 1972. In 1987, amendments to the CWA added section 402(p), which established a framework for regulating non-point source stormwater discharges under the National Pollutant Discharge Elimination System (NPDES). The NPDES stormwater program is described below.

State and Regional

NPDES General Construction Activities Stormwater Permit Requirements

In California, the NPDES Stormwater Program is administered by the California Regional Water Quality Control Boards. Dischargers whose projects disturb 1 or more acres of soil or whose projects disturb less than 1 acre, but are part of a larger common plan of development that in total disturbs 1 or more acres, are required to obtain coverage under the General Permit for Discharges of Stormwater Associated with Construction Activity (*Construction General Permit, 99-08-DWQ*). Construction activities subject to this permit include clearing, grading and disturbances to the ground, such as stockpiling, or excavation, but do not include regular maintenance activities performed to restore the original line, grade, or capacity of the facility.

The Construction General Permit requires the development and implementation of a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP must list Best Management Practices (BMPs) that the discharger will use to protect stormwater runoff and their placement. The SWPPP must also contain a visual monitoring program, a chemical monitoring program for "non-visible" pollutants to be implemented if there is a failure of BMPs, and a sediment monitoring plan if the site discharges directly to a water body listed on the 303(d) of the Clean Water Act list for sediment.

Local

Inyo County Code Section 18.77

Inyo County Code Section 18.77 regulates water transfers undertaken pursuant to Water Code Section 1810 (Sales of Surface Water or Groundwater by the City of Los Angeles, and the Transfer or Transport of Water from Groundwater Basins Located in Whole or in Part Within). Section 18.77.015 describes the conditional use permit (CUP) requirements:

> "Any person who proposes a transfer or transport of water described in Section 18.77.010. A. shall, prior to the commencement of the water transfer or transport, first apply for and obtain from the County Planning Commission a conditional use permit as provided in Chapter 18.81 of this Code. (Ord. 1004 § 6, 1998: Ord. 943 § 4 (part), 1994.)"

The proposed project requires a CUP (as stated in Chapter 2: Project Description, of this EIR) for the transfer of water from the Rose Valley Groundwater Basin to the Coso Groundwater Basin. That CUP is subject to all of the provisions of Chapter 18.77 of the Inyo County Code.

Section 18.77.045 of the Inyo County Code states:

> "In the event that evidence obtained through the monitoring and/or reporting program, or other evidence, indicates that a water transfer subject to a conditional use permit has unreasonably affected, or has the potential to unreasonably affect, the overall economy or the environment of the county, or that there has been a failure to comply with the provisions of the permit, the county planning commission shall conduct a noticed public hearing into the matter. If at the conclusion of the hearing, the commission finds that an existing water transfer, if continued, would cause an unreasonable effect on the overall economy or the environment of the county, the commission shall modify the provisions of the conditional use permit to the extent that it finds to be necessary to avoid the occurrence of such an effect. If the commission finds that a water transfer, subject to a conditional use permit has unreasonably affected the overall economy or the environment of the county, the commission shall order the implementation of such mitigation measures as it finds to be necessary to reduce the level of the effect to less than significant; in addition, the commission may modify the conditional use permit to the extent that it finds to be necessary to avoid the occurrence of such unreasonable effects in the future."

The Planning Commission may *revoke* the CUP if it finds that the water transfer can not be conducted without having an unreasonable effect on the economy or environment of Inyo County.

Section 18.77.055 of the Inyo County Code allows any party to challenge the ongoing transfer of water by alleging that the permitee is in violation of its permit requirements or that the transfer project is unreasonably affecting, or has the potential to unreasonably affect, the overall economy or environment of Inyo County.

General Plan

The Inyo County General Plan (Inyo County 2001) Conservation and Open Space Element goals and policies relevant to hydrology and water quality are listed below.

- **Conservation and Open Space Element:**
  - Goal WR-1 Provide an adequate and high quality water supply to all users within the County.
  - Policy WR-1.4 *Regulatory Compliance:* Continue the review of development proposals and existing uses to the requirements of the Clean Water Act, LRWQCB, and local ordinances to reduce polluted runoff from entering surface waters.
  - Goal WR-2 Protect and preserve water resources for the maintenance, enhancement, and restoration of environmental resources.
  - Policy WR-2.1 *Restoration:* Encourage and support the restoration of degraded water surface and groundwater resources.
  - Goal WR-3 Protect and restore environmental resources from the effects of export and withdrawal of water resources.
  - Policy WR-3.2 *Sustainable Groundwater Withdrawal:* The County shall manage the groundwater resources within the County through ordinances, project approvals and agreements, ensure adequate, safe and economically viable groundwater supply for existing and future development within the County, protect existing groundwater users, maintain and enhance the natural environment, protect the overall economy of the County, and protect groundwater and surface water quality and quantity.

3.2.3 THRESHOLDS OF SIGNIFICANCE

The project would have a significant impact if it would:

1. Deplete groundwater supplies in a manner that would result in substantial effects to existing groundwater supplies or users
2. Substantially reduce the amount of water available to surface water bodies at Little Lake Ranch and to other areas in the Rose Valley
3. Substantially alter the existing drainage pattern in the project area in a manner which would result in substantial erosion or siltation on- or off-site
4. Cause substantial flooding that could result in damage to life or property
5. Cause a violation of water quality requirements or otherwise degrade existing water quality in the area or impact drinking water and drinking water supplies

These potential impacts are discussed in the following section.

3.2.4 IMPACTS AND MITIGATION

Potential Impact 3.2-1: The potential to deplete groundwater supplies in a manner that would result in substantial effects to existing groundwater supplies or users

Overview of Impacts

The project would include water use during construction of the proposed pipeline. No significant construction-related impacts to the groundwater resources of Rose Valley are anticipated.

Potentially significant impacts to groundwater resources are predicted from operation of the project. Full project development would involve extracting groundwater from the two Hay Ranch wells at a combined total rate of approximately 4,839 acre-ft each year for the planned project duration of 30 years. The principal impact from operation of the project would result from groundwater table drawdown induced by groundwater pumping at the Hay Ranch property. Local groundwater users within Rose Valley may also experience a drop in groundwater level and could be impacted by the project. Mitigation is defined to avoid significant effects (see below). Impacts to groundwater users in the Indian Wells Basin, which receives groundwater underflow from the Rose Valley, would be less than significant, as underflow from Rose Valley is only a small portion of the water budget for the groundwater in Indian Wells Valley.

Lowered groundwater levels could have a significant impact on water availability at Little Lake Ranch, located 9 miles south of the project area. Mitigation has been defined to monitor groundwater levels through the life of the project and to re-equip or re-drill any wells that are impacted by groundwater drawdown caused by the project.

Effects to water levels in Little Lake and the surrounding springs and wetlands are discussed under Potential Impact 3.2-2.

Construction

Construction of the project would consist of installing downhole pumps in the two existing Hay Ranch wells, installing permanent electrical service to the two well heads, and constructing a water delivery pipeline and storage tanks from the Hay Ranch property for approximately 9 miles east, to the Coso geothermal field. Water would be needed primarily for dust control and concrete mixing during construction. Construction is estimated to take approximately 110 days. Daily water needs would be unlikely to exceed 15 truckloads (approximately 45,000 gallons), which can be obtained from wells owned by COC at Coso Junction, or the Coso Ranch south well (located opposite the Coso store). These wells are currently used to provide water by the truck load to the nearby pumice mine operation.

The increased groundwater demand during construction (at 45,000 gallons per day or approximately 30 gpm on a continuous basis) would have no measurable impact on other groundwater users in the valley. The total volume of groundwater (approximately 15 acre-feet) potentially consumed during construction of the project would have no significant impact on water resources in the valley because the amount of groundwater available is several thousands of acre-feet. During the pumping test performed in November and December 2007, about 88 acre-ft of water was pumped and applied to the surface on the Hay Ranch property with no measurable effect to wells off of the Hay Ranch property (see Appendix C1 for pumping test description and results).

The construction contractor may also elect to install a small temporary pump in one of the Hay Ranch wells to supply construction water. The impact of pumping either one of the Hay Ranch wells at a rate of 30 gpm during construction is unlikely to occur off of the property. No other groundwater would be needed during construction. Impacts would be less than significant.

Operation and Maintenance

The principal impacts from operation and maintenance of the proposed project would be from groundwater pumping and subsequent transfer of that groundwater from one basin (Rose Valley) to another (Coso Basin). Potential impacts to groundwater users are discussed below for users within Rose Valley and Indian Wells Valley to the south.

Operation of the substation and associated facilities (buildings), water storage tanks, and pipeline would not have an impact on groundwater supplies beyond the actual groundwater pumping. These project components would create approximately 3 acres of new impervious surface; however, given the vast amount of undeveloped acreage in the area, recharge to groundwater would not be significantly impacted. The substation would include a MEER that may have a bathroom facility. A few gallons of water per day would be required for the bathroom facility and would likely be stored in a small tank near the facility and produced by the Hay Ranch wells or another nearby supply (e.g., the Coso Store well, or the Coso Ranch well, or purchased). Water use for domestic purposes at the facilities would not significantly impact groundwater supplies in the project area.

Potential Impacts to Groundwater Users within Rose Valley. Groundwater pumping, as proposed, could result in reduced groundwater levels in Rose Valley. The number of existing groundwater users in the valley is limited due to limited development in the area. An estimated 40 acre-ft/yr of groundwater is currently produced from groundwater wells in Rose Valley. Dunmovin area may have as many as 30 domestic wells. Other wells include those owned by LADWP, Cal-Pumice, Coso Ranch (north and south well), northern and southern Coso Junction store well, and the Caltrans well at Coso Junction. At the south end of Rose Valley, the Red Hill well on Cinder Road is believed to be used for domestic purposes. Wells on the Navy property in Rose Valley, including the Lego well, well G-36, and well 18-28. There are also water wells on Little Lake property. Not all of the wells in the valley are in use.

Numerical groundwater flow modeling analysis was conducted to evaluate potential impacts of project operation on groundwater levels throughout the valley. The flow modeling analysis is described in Appendix C2. A four-layer model was constructed, with Layers 1 and 2 representing recent alluvial sediments, Layer 3 the Coso Lake Bed, and Layer 4 the Coso Sand unit. The upper layer is simulated as an unconfined aquifer and the three lower layers simulated as confined units. In general, Layers 1 and 2 have substantially higher values of hydraulic conductivity in the model and most of the groundwater flow occurs in these upper layers.

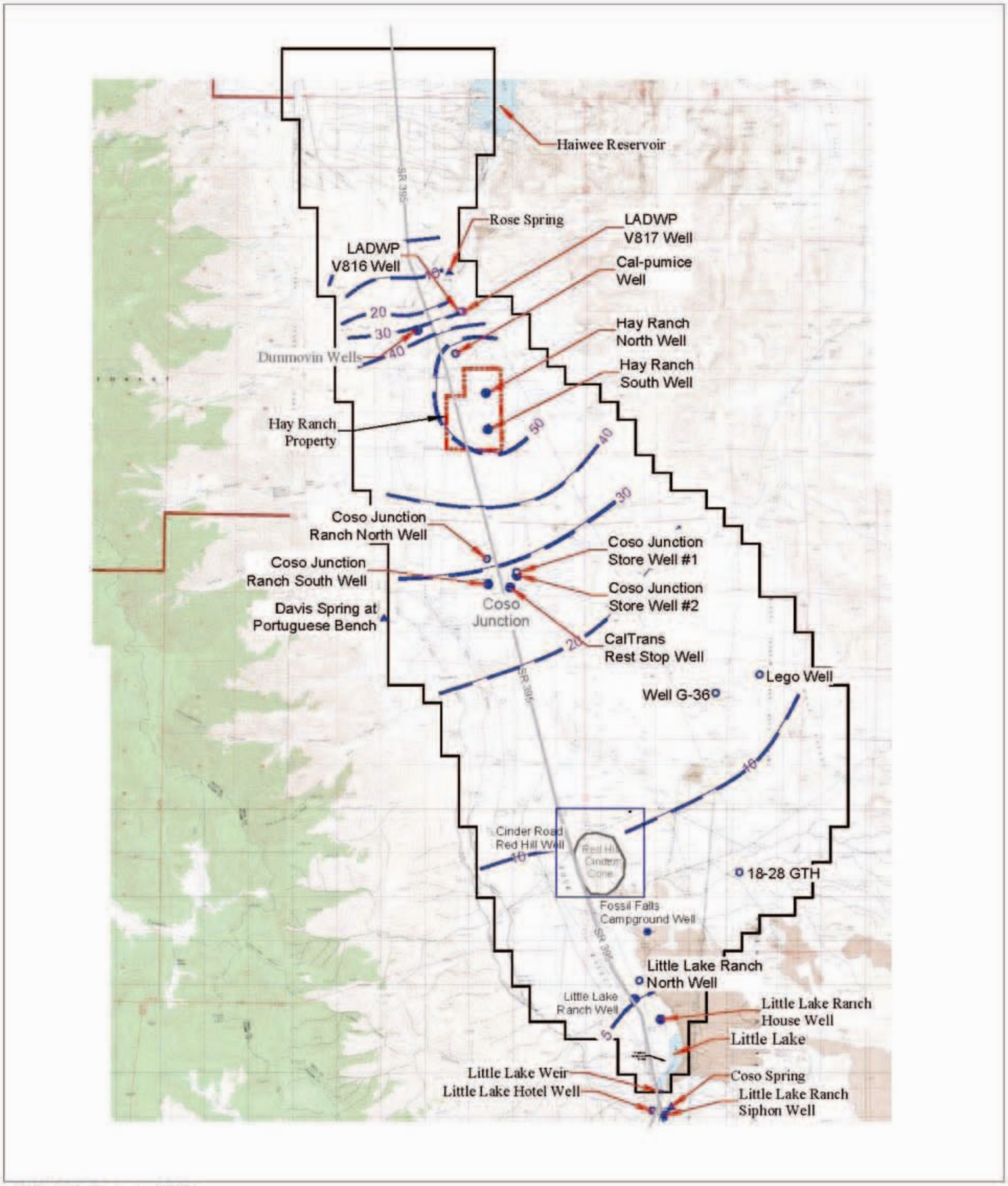
The predicted groundwater table drawdown developed after 30 years of pumping the Hay Ranch wells at the full project development rate of 4,839 acre-ft/yr is depicted in plan view on Figure 3.2-14. Predicted drawdown in groundwater levels in various wells after full project development is shown in Table 3.2-5.

The range in predicted drawdown impacts reflects uncertainty in assumed values for aquifer specific yield (a measure of the aquifer’s ability to release groundwater from storage); low specific yield values result in greater drawdown in groundwater levels that would occur and would be observed sooner than if the aquifer has a high specific yield. Higher specific yield values result in less drawdown with time and less drawdown farther from the pumped wells. There may be additional uncertainty associated with the existing limited knowledge of the transmissivity, recharge, and evapotranspiration values.

These estimates of predicted drawdown may be conservative because of several conservative assumptions used in the model:

1. The groundwater flow into Rose Valley from Owens Valley is presumed to be underestimated (see water budget discussion associated with Table 3.2-3)
2. The model does not include any flow from Coso Basin, although the isotopic studies showed that there is evidence of geothermal fluids in the Little Lake area
3. The estimate of evapotranspiration from the Little Lake area is high
4. The model assumes a low precipitation recharge rate from the Sierra Nevada mountains west of the valley
5. The model neglects potential precipitation recharge from the Coso Range on the east side of the valley and neglects precipitation recharge falling directly on the valley floor
6. The model uses a low estimate for groundwater underflow from Owens Valley to the north

Figure 3.2-14: Predicted Groundwater Table Drawdown After 30 Years at Full Project Development Rate of 4,839 acre-feet/year



SOURCE: Geologica 2008

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Table 3.2-5: Predicted Maximum Drawdown in Wells in Rose Valley at Full Pumping Rate for 30 Years

Location	Distance from Hay Ranch Wells	Predicted Maximum Drawdown
Wells in Dunmovin and LADWP wells	1.5 miles north	25 to 55 feet
Coso Junction wells	2 miles south	20 to 50 feet
Cinder Road/Red Hill well	6.5 miles south	7 to 20 feet
Little Lake Ranch North well	8.5 miles	4 to 11 feet

In contrast, uncertainties in the value of specific yield could cause the predicted drawdown values to be somewhat greater than predicted. Uncertainties in transmissivity, recharge and evapotranspiration could cause the predicted drawdown to be either higher or lower. The effect of uncertainties in the model results is discussed later.

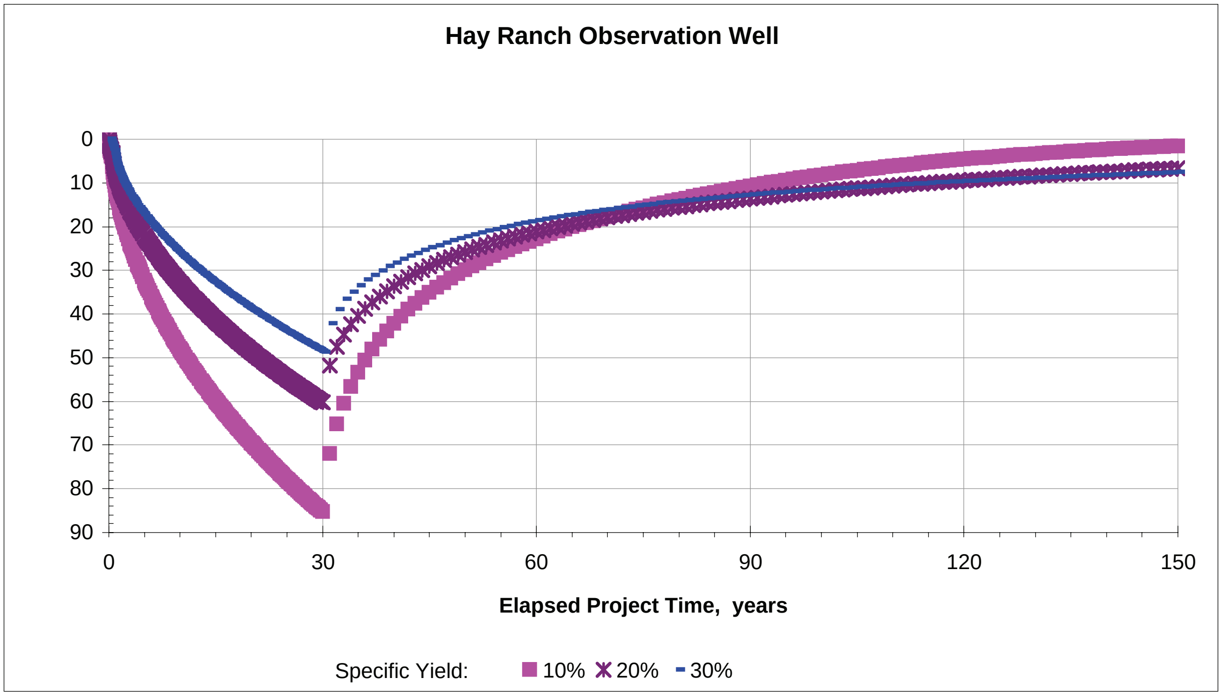
Groundwater-yielding sediments encountered in Rose Valley consist primarily of sand and gravel interbedded with clays. Most of the groundwater is expected to be produced from the more readily drainable sand and gravel horizons. Published values of specific yield (Johnson 1967; Morris and Johnson 1967) range from 2 percent for clay to 35 percent for well-graded gravels. Because specific yield could not be determined from the pumping test data, a range of values corresponding to expected high, medium, and low values of 30, 20, and 10 percent for model Layer 1 were used in the groundwater modeling that was conducted for this impact analyses. The deeper hydrostratigraphic units (model Layers 2, 3, and 4) were represented by lower values of storage coefficient (specific yield), which reflect confined aquifer conditions (see Appendix C-2 for a more complete discussion).

Groundwater table drawdown would increase with time following startup of the project. The modeling results indicate that, depending on aquifer specific yield, the impact of pumping at Hay Ranch would take more time to develop at locations farther from Hay Ranch. At locations farther from Hay Ranch, the maximum drawdown may develop after pumping at Hay Ranch has stopped. Figure 3.2-15 shows that the maximum drawdown on the Hay Ranch property is predicted to occur at the end of the 30 year project pumping period, whereas the time at which the predicted maximum drawdown occurs is delayed for areas farther south of Hay Ranch. The maximum predicted drawdown at wells at Little Lake (9 miles south of Hay Ranch) is expected to occur up to 30 years after pumping at Hay Ranch stops. This delay period is also dependent on specific yield. The delay would be shorter for lower specific yield values and longer for higher specific yield values.

The predicted changes in groundwater table drawdown over time in wells in the community of Dunmovin, Coso Junction, the Red Hill well on Cinder Road, and Little Lake Ranch North are shown in Figure 3.2-15.

Groundwater pumping and transfer, as proposed, would have a potentially significant impact on other groundwater users in Rose Valley by lowering the groundwater table in the vicinity of their wells and therefore potentially inhibiting access to groundwater. Due to the low level of predicted groundwater table drawdown (less than 10 feet), water supply wells at the south end of Rose Valley may not need any equipment changes. Although well construction details were not available for most of the wells in the valley, most of the wells appear unlikely to need to be deepened because the maximum drawdown predicted off the property is less than 40 feet and most wells have a water column of 100 feet or more. However, for wells in the Dunmovin area and in Coso Junction, existing pumps might have to be set at lower depths, or existing pumps might need to be replaced with pumps with greater lift capacity.

Figure 3.2-15: Predicted Groundwater Elevation Changes with Time in Wells in Rose Valley for Pumping at 4,839 Ac-Ft Per Year for 30 Years



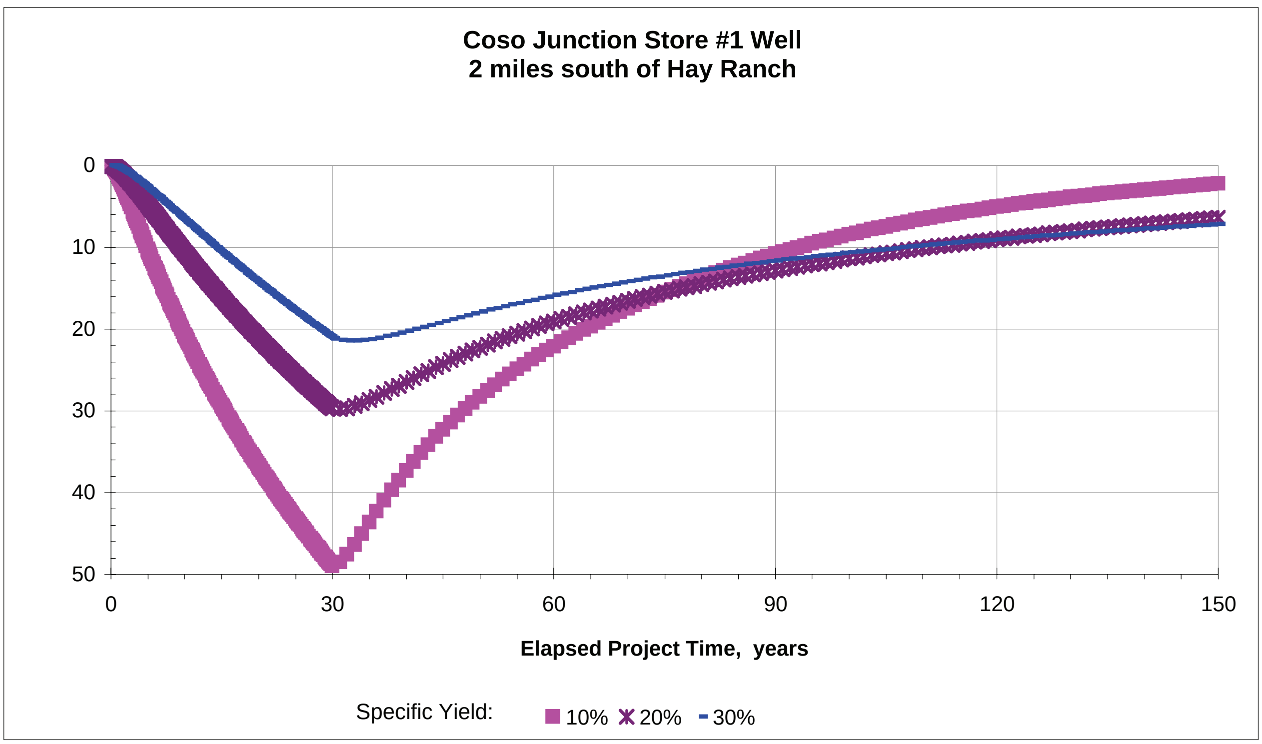
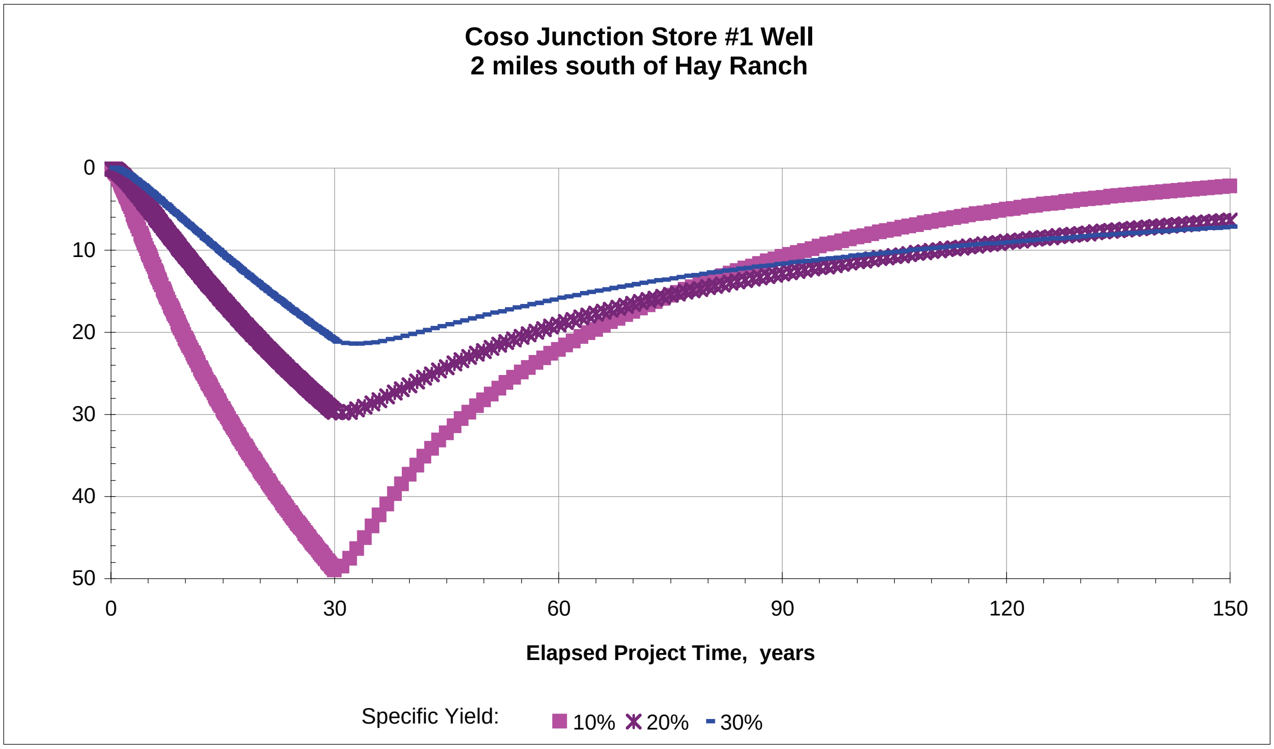
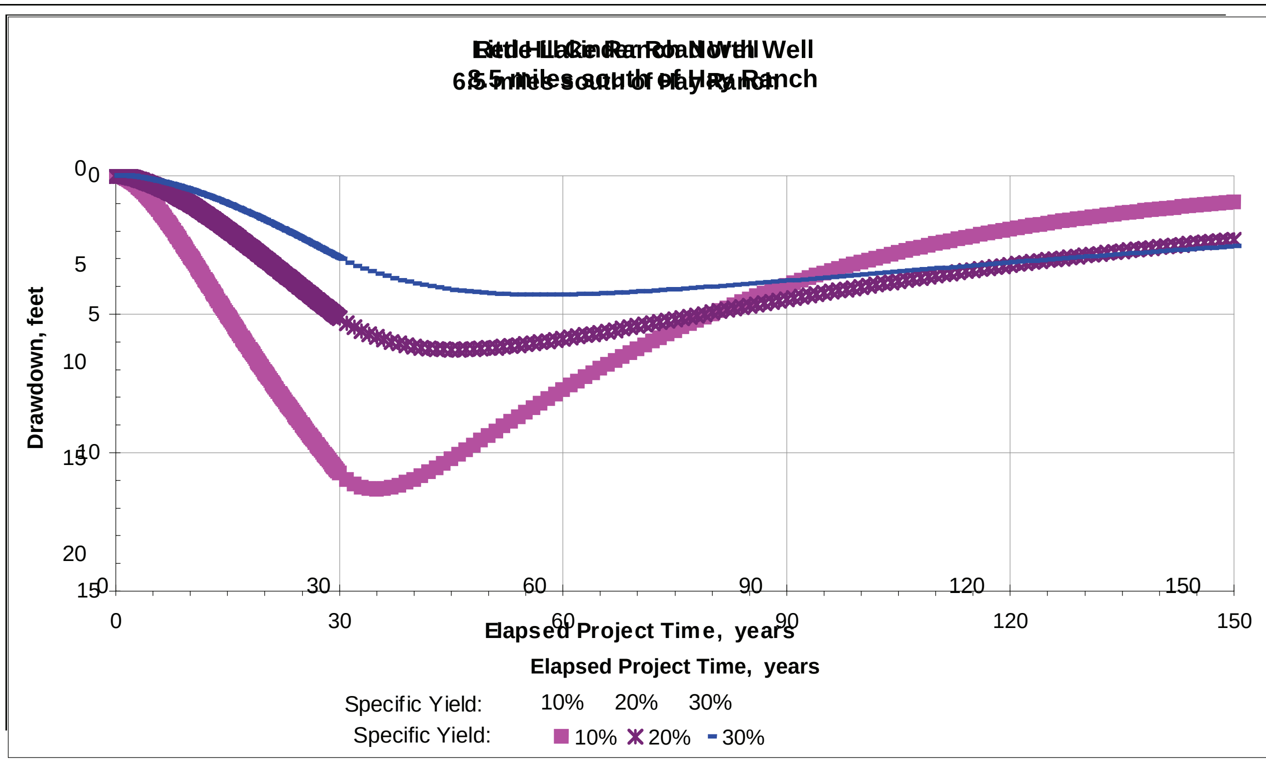


Figure 3.2-15 *(Continued)*: Predicted Groundwater Elevation Changes with Time in Wells in Rose Valley Pumping at 4,839 Ac-Ft Per Year for 30 Years





SOURCE: Geologica 2008

Mitigation described below requires that the applicant fund any well adjustments through the life of the proposed project for any existing wells that lose their current functionality as a result of the proposed project. The mitigation would minimize impacts of the proposed project on access and use of existing wells in the Rose Valley to less than significant levels. Monitoring would also occur to track groundwater drawdown as a result of the proposed project in order to determine when and if mitigation would be needed.

> **Hydrology-1:** The project applicant shall finalize and implement the Draft Hydrological Monitoring and Mitigation Program (HMMP) included in Appendix C4 of this EIR.
>
> **Hydrology-2:** Mitigation for effects to groundwater wells in Rose Valley shall depend upon the specific characteristics of each well, and the use of the well. The applicant shall use monitoring data and the numerical groundwater flow model described in Appendix C2 to track groundwater levels throughout the valley. The applicant shall work with the County Water Department to identify wells that may be affected by groundwater drawdown as the project progresses. The evaluation of wells depths and uses in the Rose Valley as compared with groundwater drawdown shall be made semi-annually and reported to the Inyo County Water Department. The owner of any wells that may potentially be impacted within the six months after an evaluation shall be contacted by the applicant to assess the need for additional pumping equipment on the well or deepening of the well. The applicant shall be responsible for the cost of equipping or deepening wells that are impacted by groundwater drawdown as a result of the proposed project. The applicant shall also evaluate any wells that are brought to the attention of the applicant by the user to evaluate if groundwater drawdown from the proposed project is impacting the well. If it is determined by the County or by the applicant (using well monitoring data and modeling) that the well in question is being impacted by the proposed project, the applicant shall fund the necessary adjustments to the well to secure the previous uses of the well. Disputes as to the cause of well water drawdown or appropriate corrective measures shall be resolved by the County.

Potential Impacts to Groundwater Users in Indian Wells Basin

The project would result in a reduction in the amount of groundwater flowing south to the Indian Wells Valley. Impacts to groundwater users in Indian Wells Valley, which receives groundwater underflow from the Rose Valley, would be less than significant, as discussed earlier. Underflow is only a small portion of the groundwater budget in Indian Wells Valley. The predicted reduction in groundwater underflow to Indian Wells Valley ranges from 377 acre-ft/yr at a specific yield of 30% to 1,300 acre-ft/yr at a specific yield of 10% at the full project development rate and 30 year project duration. These values are less than 3% of the total recharge of 46,000 acre-ft per year estimated by Williams (2004) for the Indian Wells Valley. If mitigation is implemented, for example in the form of reducing or ceasing Hay Ranch pumping after 1.2 years of pumping (discussed in Potential Impact 3.2-2), even less impact to groundwater users in Indian Wells Valley is predicted.

Decommissioning

Decommissioning would involve removing above ground project components, including the tanks and the equipment on the Hay Ranch property, and abandoning the pipeline in-place. Pumping of the Hay Ranch wells would terminate and no more water would be transported out of the basin as part of the proposed project. Impacts to groundwater drawdown would cease in much of the valley as the aquifer begins to refill; however, due to the lag effect in the more distant portions of the valley, such as Little Lake, some additional drawdown will occur for a few years following cessation of pumping. The lag effect could continue for as much as 30 years after pumping before the maximum drawdown is reached, based on modeling results. Groundwater levels would eventually rise throughout the valley; however due to the lag effect discussed above, groundwater levels in the more distant areas, such as the south end of the valley, would recover more slowly and could take more than 30 years to recover fully after pumping ceases. The rate of groundwater table elevation recovery also depends on aquifer specific yield; as depicted on Figure 3.2-15, groundwater elevation would recover more quickly if specific yield is low (10%) than if it is high (30%). Groundwater recovery throughout the valley would occur more rapidly if less groundwater was withdrawn for the project (e.g., if the project was terminated early or Hay Ranch pumping rates were reduced before the end of the 30 year project life). Impacts of decommissioning itself would be less than significant, although there would be a delayed recovery to the cessation of pumping in many areas.

Potential Impact 3.2-2: The potential to substantially reduce the amount of water available to surface water bodies at Little Lake Ranch and to other areas in the Rose Valley

Overview of Impacts

Construction would not have impacts on surface waters or springs because only a relatively small amount of water is needed for dust suppression and other construction activities. There are no surface waters near the project site that would be used as a water supply for construction or that could be impacted by construction.

During the operation phase and post-operation recovery phase, the principal potential impacts to surface water flows include possible reduction or elimination of spring or siphon well/spring flows in certain locations and the reduction in water available to Little Lake Ranch.

Because they are located at much higher elevations than the groundwater table in the Rose Valley aquifer, the Tunawee Canyon and the Davis spring/siphon well at Portuguese Bench, as well as Rose Spring, located 2 miles north of the proposed project are, are unlikely to be impacted by the proposed project. However, numerical modeling analysis presented in Appendix C2 indicates long term operation of the project could impact water levels and surface water discharge on the Little Lake Ranch property.

Water availability at Little Lake Ranch could be impacted by the proposed project. The HMMP (as described in mitigation measure Hydrology-1) would be implemented to monitor and identify potential effects to water availability at Little Lake Ranch.

Mitigation for the effects of pumping at Hay Ranch is defined in Mitigation Measure Hydrology-4 and includes:

1) Monitoring and recalibration of the groundwater model to improve model predictions. The model recalibration shall be conducted within the first year, and then at a frequency of every 5 years or less for the duration of pumping operations, as needed or as directed by the Inyo County Water Department. The recalibration shall be conducted sooner if actual drawdown in two or more monitored wells is at least 0.25 feet higher than predicted by the model for those locations. New predicted drawdown values shall be calculated based on the recalibrated model, and an evaluation shall be made whether reduced pumping rates and/or duration is necessary.
2) Reducing pumping rates and/or duration after project startup as determined by the Inyo County Water Department based on a more accurate model and triggers defined to prevent the threshold of significance from being reached.

Mitigation would minimize potential impacts to water availability at Little Lake Ranch and surrounding surface waters, wetlands, and springs to less than significant levels.

Construction

Construction of the project is unlikely to impact surface waters, springs, or surface water discharge rates at Little Lake because of the short duration (110 days), relatively small amount of groundwater potentially needed for construction related purposes, and distance (over 9 miles) from the project well locations. Groundwater may be used for dust suppression at an estimated maximum of 15 acre-feet over the course of the project construction. Pumping tests in November and December 2007 withdrew about 88 acre-feet of water and applied it to the surface with no discernable impact to surface springs or waters off of the Hay Ranch property. Construction water use would not impact water levels in surface waters or springs.

Operation and Maintenance

The principal impact in Rose Valley from operation and maintenance of the proposed project would be from groundwater table drawdown off the property resulting from removing groundwater from the Hay Ranch property and transporting it outside the Rose Valley groundwater basin (to the Coso Basin). Operation of the substation and associated facilities (buildings), water storage tanks, and pipeline would not have an impact on surface water supplies unrelated to groundwater pumping.

Springs, siphon wells, and surface waters in the project region include:

- Tunawee Canyon Spring at Portuguese Bench
- Davis Spring and siphon well at Portuguese Bench
- Rose Spring
- Little Lake, springs, and siphon well

Potential Impact to Springs. The Tunawee Canyon and the Davis spring/siphon well at Portuguese Bench would not be impacted by the proposed project because they are located at much higher elevations than the groundwater table in the Rose Valley aquifer. Portuguese Bench is located approximately 600 feet in elevation above the groundwater table level at the Hay Ranch property. The well at the Davis Ranch was monitored during the November/December 2007 pumping tests and no effects were identified (see Appendix C1). Given the artesian flow at the wells on Portuguese Bench, proximity to the Sierra Nevada, and elevation of over 600 feet above groundwater level at Hay Ranch, water supplying the wells at Portuguese Bench is not hydrologically dependent on the water in the Rose Valley. The springs and wells on Davis Ranch and Portuguese Bench would not be impacted by the proposed project.

Rose Spring, located approximately 2 miles north of the Hay Ranch property at an elevation of 3,580 feet amsl ,is apparently perched groundwater and is approximately 300 ft above the local elevation of the groundwater table in the aquifer. Because it is perched far above the water table, it is unlikely to be impacted by the proposed project. The source of water for the spring is derived from Sierra Nevada mountain front precipitation and groundwater underflow from Owens Valley, neither of which is likely to be impacted by pumping at Hay Ranch. Recent monitoring indicates that there is currently no surface water flowing at Rose Spring (EREMICO 2008).

Potential Impacts to Water Availability at Little Lake Ranch. Impacts to Little Lake Ranch could occur through substantially reduced water availability to Little Lake and/or through substantially reduced water flow to the lower ponds.

Surface waters at Little Lake Ranch could be impacted by operation of the proposed project. Surface water flows on the Little Lake Ranch property are sustained entirely by groundwater inflow that rises to the surface in the area. The source of the groundwater that discharges to Little Lake is estimated to be primarily (more than 80%) from Sierran recharge to Rose Valley coming from the west, in addition to some groundwater upwelling from the Coso Basin to the east (as much as 250 acre-ft/year) and some amount of underflow from the north of Rose Valley (an estimated 898 acre-ft/yr).

The groundwater beneath the Hay Ranch property primarily originates as precipitation recharge in the Sierra Nevada Mountains north and west of the property with some contribution from groundwater underflow from north of Rose Valley and upwelling geothermal water from the Coso Range. The groundwater elevation and flow rate towards Little Lake Ranch could be reduced by pumping at Hay Ranch. Flow rates towards Little Lake Ranch could be reduced because pumping at Hay Ranch would capture some of the groundwater flow from Owens Valley and the Sierran recharge in the north end of the valley. Capture of water at Hay Ranch could create northerly groundwater table gradients near Hay Ranch that could reduce the natural southerly groundwater gradients towards the south end of the valley where Little Lake is located.

Table 3.2-6 provides a breakdown of the sources of water captured by the Hay Ranch wells at the full project development rate of 4,839 acre-ft/year, based on modeling results. The results indicate that capture of groundwater at Hay Ranch that normally flows toward the Little Lake Gap would reduce groundwater elevations and groundwater flow rates towards Little Lake. Further explanation of the model is provided in Appendix C2.The model results indicate that at the full design rates, the project would reduce groundwater flow and table elevation on the Little Lake property.

Relationship between Groundwater and Surface Water at Little Lake Ranch. Groundwater table drawdown at the Little Lake Ranch property would likely reduce water available to the lake, which could potentially cause water levels in the lake and ponds to fall. One stated goal of the 2000 Habitat Restoration and Improvement Plan (ULLR 2000) is to protect and increase the effective use of surface water on the ranch. The plan outlines methods to further increase the property's wetland acreage and total surface area of impounded water through better control of water flowing through the property. A substantial decrease in the lake size due to reduced availability of groundwater would negatively impact habitat restoration efforts and would be considered a potentially significant effect.

Bauer (2002) found that the groundwater elevation in the well on the north shore of Little Lake (Little Lake North Dock well) was consistently 3 feet higher than the lake level, indicating that the lake gained water from the aquifer year-round. These data suggest that groundwater table drawdown of 3 feet or more could reverse the direction of water exchange such that the lake would begin losing water to the aquifer and cause a reduction in surface area. There is about 1 foot of natural variation in groundwater level at the North Dock well (Bauer 2002).

Table 3.2-6: Sources of Water Captured by Hay Ranch Wells after 30 Years of Pumping at full Project Rate of 4,839 Acre-ft/yr

	Specific Yield Values Used in Model		
	10% (acre-ft/yr)	**20% (acre-ft/yr)**	**30% (acre-ft/yr)**
Increased Groundwater Underflow from the North (Owens Valley)	26	6	3
Soil Pore Drainage (Aquifer drawdown)	3,071	3,994	4,343
Reduced Groundwater Underflow to Indian Wells Valley from Southeastern Rose Valley	50	18	8
Reduced Evapotranspiration at Little Lake	379	183	107
Reduced Groundwater Discharge through Little Lake Gap to Indian Wells Valley	1,313	638	377
TOTAL	**4,839**	**4,839**	**4,839**

NOTE: Water budget components calculated from numerical model output files using Groundwater Vistas Mass Balance audit feature.
SOURCE: Geologica 2008

The numerical modeling results predict that groundwater table drawdown will increase with time following startup of the project. The modeling results indicate that, depending on aquifer specific yield, the impact of pumping at Hay Ranch takes greater time to develop at locations farther from Hay Ranch. At locations farther from Hay Ranch, the maximum drawdown may develop after pumping at Hay Ranch has stopped. The maximum drawdown on the Hay Ranch property near the production wells is predicted to occur at the end of the 30 year project pumping period, whereas the predicted maximum drawdown at Little Lake, 9 miles south of Hay Ranch, may not appear for up to 30 years after pumping at Hay Ranch stops (as shown on Figure 3.2-15). This delay period is also dependent on specific yield and is shorter for low specific yield and longer for high specific yield. The predicted changes in groundwater table drawdown at the northern end of Little Lake (North Dock well) with time during and after the 30 year project life are shown in Figure 3.2-16. The currently predicted drawdown at Little Lake North Dock well for full project pumping at a rate of 4,839 ac/ft per year for 30 years ranges from 3 to nearly 8 feet depending on assumed specific yield. Drawdown greater than 3 feet could result in a reverse in the natural flow pattern and could drain the lake, which would be a significant impact. Even drawdowns of less than 3 feet in the vicinity of Little Lake could cause a reduction in lake level and the surface area of the lake because groundwater flow to the lake would decrease as the hydraulic gradient to the lake decreased. A reduction in the amount of groundwater discharging to the lake could cause the water budget in the lake to be in deficit, potentially resulting in a significant drop in lake level and reduction in surface water area, which would be considered a significant effect.

Groundwater Flow Reduction towards the Little Lake Gap. Pumping as proposed at Hay Ranch could also result in reduction in the amount of groundwater flowing towards Little Lake Gap. Groundwater discharge towards the Little Lake Gap would be reduced from the current estimated value of 4,200 acre-ft/yr to between 2,500 and 3,700 acre-ft/yr at the full project pumping rate (4,839 acre-ft/yr) and duration (30 years). The effect of full project development on water table level in the vicinity of Little Lake is shown on Figure 3.2-17.

A reduction in groundwater flow could also impact the discharge rates from the lake, which currently flows over the weir into the lower pond areas during the winter and spring months. A reduction in groundwater flow could also reduce the discharge rate of water from the lower siphon well and Coso Spring, located about ¼ mile south of the Little Lake weir. The spring and siphon well are about 20 feet lower in elevation than the northern end of the lake, so groundwater drawdown here would be much less than in the northern end of the lake (refer to Appendix C2). Because of the damming of Little Lake, the water table elevation is somewhat buffered below the lake, and the springs tend to flow year round, even when the lake is not discharging over the weir.

The Little Lake Ranch habitat restoration effort receives, on average, less than 25% of the water it uses for irrigating the lower property from discharge from Little Lake. The bulk of the water used for downstream restoration efforts comes from Coso Spring and the siphon well. Data from Bauer (2002) indicates that, when the lake stops discharging over the weir, the groundwater continues to discharge from the spring and siphon well. In 1997, there were 3 consecutive summer months when there was no downstream flow from Little Lake. During that time, Coso Spring had its highest monthly flows (2,000 acre-ft/yr). If the Hay Ranch project causes reduction in groundwater flows towards Little Lake, it will reduce the amount of groundwater coming to the surface on the Little Lake Ranch property. As a result, the discharge rate from Little Lake would likely decrease and groundwater that previously surfaced at the lake would likely surface farther south on the property at the siphon well and Coso Spring (increasing the proportion of water discharging from the spring and siphon well compared to the lake).

Figure 3.2-16: Predicted Groundwater Table Drawdown at the North End of Little Lake Pumping at 4,839 Ac-Ft Per Year for 30 Years

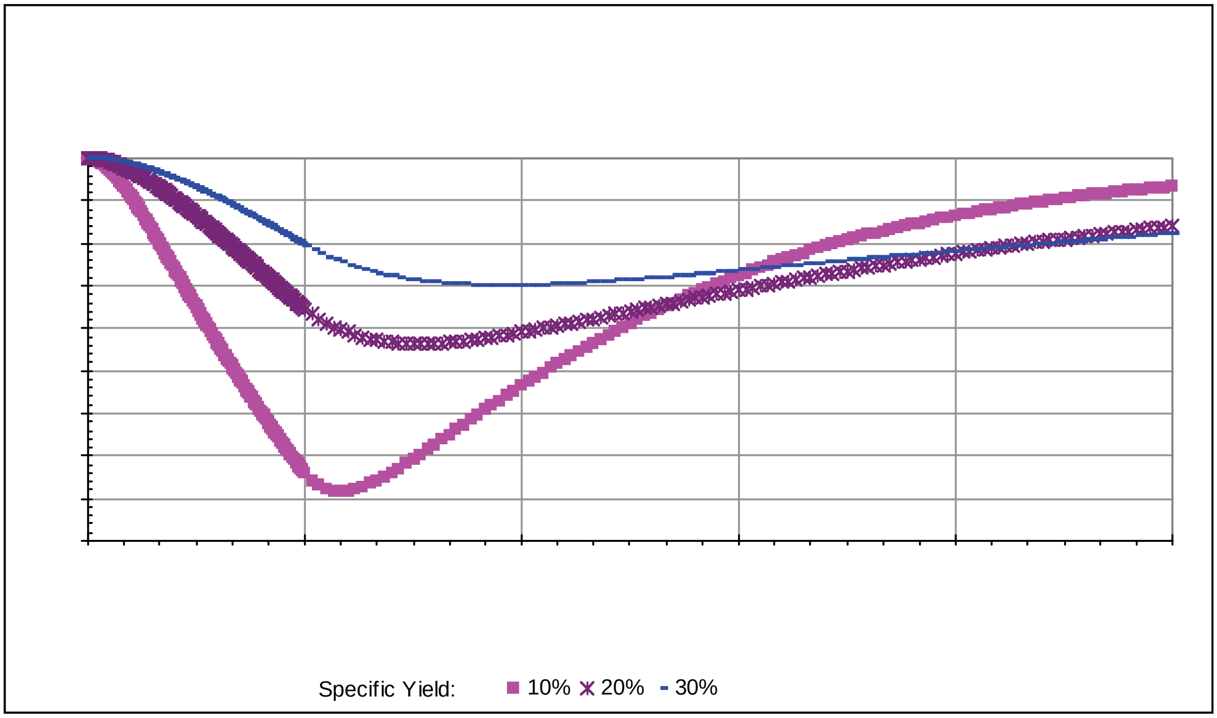
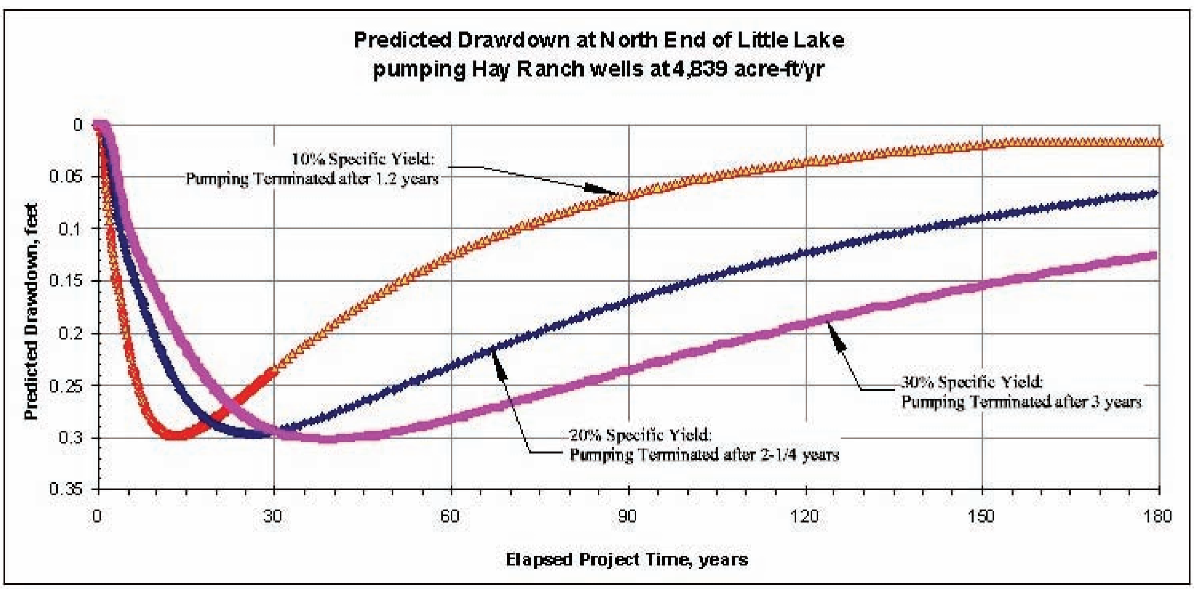


Figure 3.2-17: Early Pumping Termination (1.2 years) Scenario Results



The amount of groundwater surfacing on the property could be reduced substantially under full pumping rates and project duration. A relatively small reduction in the flow rate and overall saturated thickness of the aquifer caused by water table lowering could cause water that previously surfaced to remain below ground. Reduced groundwater flow rates through the lower part of the property would reduce the amount of water that Little Lake Ranch would have to perform their restoration efforts, which could be considered a significant impact.

Definition of a Significant Impact to Water Availability at Little Lake Ranch. Defining thresholds of significant effects to the environment by attempting to measure or predict those effects on vegetation around Little Lake Ranch was considered and rejected. The Little Lake area is highly manipulated. Water levels of the Little Lake reservoir are manually controlled. The vegetation surrounding the area south of Little Lake is manipulated by removing undesirable species, planting others and by moving water to various areas where managers intend to promote vegetation. As a result, there is no natural background condition against which to measure effects. Additionally, by moving water around the property, vegetation may be encouraged in areas not currently highly vegetated and discouraged in areas now heavily vegetated if management objectives for the restoration project shift. Therefore, by necessity, it is most appropriate to emphasize measuring impacts to the amount of water that is available to the restoration project, rather than biological indicators.

The potential effect of groundwater pumping at Hay Ranch includes reduced groundwater flows towards the Little Lake property. This could result in a reduction in water available in the lake as well as in the downstream pond areas. If the project were to result in a substantial decrease in water available to Little Lake Ranch, the project would have a significant impact. Identifying the connection between groundwater withdrawal on the Hay Ranch property and effects on surface water and water availability at Little Lake Ranch is difficult given current limitations in the understanding of the aquifer and groundwater system in the Rose Valley. The hydrologic model and existing data on the relationship between groundwater levels and water levels in Little Lake provide the best scientific basis, at present, for determining how pumping could impact the lake.

Pumping would result in a propagation of groundwater drawdown through the Rose Valley over time. Even after pumping ceases, effects would continue to propagate through the valley. In order to determine project effects, a significant impact at Little Lake must first be defined and then related to groundwater pumping and corresponding groundwater level drawdowns throughout the valley.

A benchmark of no more than a 10% decrease in discharge to Little Lake has been determined to be the “tolerance” level at the lake in order to prevent significant impacts to water availability at the lake. This groundwater flow rate reduction trigger level of 10% has been set such that the observed variation in flow rates at Little Lake would remain largely within the natural envelope already experienced on the property. Groundwater table elevations and gradients in the area vary seasonally. Bauer (2002) found that for three months of 1997 discharge from Little Lake ceased. A reduction in groundwater discharge to the lake of up to10% may extend the period that water does not flow from the lake, but during that timeframe water would still be expected to flow from the siphon well and Coso Spring. Coso Spring currently supplies water to the lower ranch area 75% of the time and, in particular, when overflow stops from Little Lake (Bauer 2002).

The lower pond areas, south of Little Lake, must also receive water to maintain the wetlands. The outflow from the spring, siphon well, and the lake that is not evaporated or consumed by plants infiltrates back into the ground. The amount of water estimated to be reentering the aquifer at the south end of the property may be as much as 3,000 acre-ft/yr, which could be manipulated to create more surface water in the lower ponds. A 10% maximum decrease in groundwater discharge to Little Lake would still allow for the vast majority of the groundwater to be available for creation of surface water features (e.g., ponds) prior to infiltration back into the aquifer. No surface waters currently exit the Little Lake Ranch property (i.e., all water entering the property infiltrates back into the ground, evaporates, or is transpired by plants on the property). Restoration efforts outlined in the 2000 plan focused on methods to capture currently flowing water prior to its infiltration back into the ground at the south end of the property.

The habitat restoration/creation efforts at Little Lake have been designed for large scale fluctuations in water availability. If the proposed project does not reduce groundwater levels by more than 10%, then it is expected that water would flow from the siphon well and Coso Spring such that downstream areas would have enough water to maintain the manipulated wetland habitats on the property. Flow over Little Lake weir may decrease or cease for a longer period of time than it does now on average. The habitat between the weir and the siphon well is usually subject to a period of ceased flows from the lake (Bauer 2002) and is, therefore, adapted to it. As long as groundwater levels fell just a few inches in this area, plants could grow deeper roots to adapt. When water begins to flow again, the area would again inundate and the wetland plants would thrive again. A 10% or less decrease in flows would allow for continued maintenance of wetland plants and habitat restoration efforts.

The project as proposed would cause a greater than 10% decrease in groundwater inflow to Little Lake based on the existing data and results of the existing model. This would be considered a significant impact. Mitigation includes establishing monitoring points and trigger levels throughout the valley such that, if actions were taken when those levels were reached, they would prevent Little Lake from ever experiencing more than a 10% loss in water availability due to groundwater pumping at Hay Ranch

Mitigation and Monitoring. The project as proposed is expected to cause a significant impact to Little Lake Ranch surface waters based on the results of the existing model and existing data on the relationship between groundwater levels and lake water levels. Based on existing knowledge of the Little Lake area and the groundwater system in the area, triggers throughout the valley that would indicate an eventual 10% decrease in flow to the lake, can be established using the model. Mitigation includes establishing monitoring points throughout the valley that if actions were taken when those levels were reached, would prevent Little Lake from ever experiencing more than a 10% loss in water availability due to groundwater pumping at Hay Ranch.

The trigger points are established based on the groundwater drawdown level that could cause a significant impact at Little Lake. Current data suggests that the groundwater aquifer is 3 feet higher than the lake level. A 10% decrease in head would result in 10% decrease in water flow to the lake. This is currently believed to be 0.3 feet of groundwater drawdown at the north end of Little Lake.

This 0.3 feet of drawdown at the Little Lake North Dock well is ***not*** the main monitoring point, but a calibration point for the model. The calibration point is necessary to establish the equivalent drawdown in areas up-valley, such that if those triggers up-valley are reached, mitigation must be implemented to prevent an eventual decrease of groundwater flow to Little Lake greater than 10%. The North Dock well is a complex location for monitoring due to its proximity to the lake and the fact that it is so far from the Hay Ranch wells. Additionally, maximum drawdown in the North Dock well would occur long after cessation of pumping at Hay Ranch. The amount of groundwater table drawdown seen at any point throughout the valley would depend mainly upon how close the point is to the Hay Ranch production wells. A 10% decrease in groundwater elevation at the north end of Little Lake would appear as a larger drawdown in groundwater levels in wells closer to Hay Ranch than in those farther from Hay Ranch. Monitoring must occur closer to Hay Ranch, in order to ensure that the lake never reaches more than 10% decrease in groundwater inflow.

The existing groundwater model predicts that, with a specific yield value of 10%, a maximum of 10% reduction in groundwater inflow to Little Lake (this is currently benchmarked to a drawdown of 0.3 feet in the Little Lake North Dock well) would occur following pumping at Hay Ranch at proposed pumping rates for a period of approximately 1.2 years. The model predicts that this maximum drawdown would occur as much as 30 years after the cessation of pumping at 1.2 years, due to the large distance (9 miles) from the pumping. Other locations closer to Hay Ranch would likely record their maximum drawdown after much shorter periods of time, as shown in Table 3.2-7. For example, if pumping ceases at 1.2 years, at the Cal Pumice well, the model predicts that maximum drawdown (7.1 feet) would be reached at approximately 1.25 years, at Coso Ranch North Well a maximum drawdown of 2.5 feet would be reached at 3 years, and at the Red Hill Cinder Road Well, the maximum drawdown would be expected to be 0.7 feet at approximately 12 years.

Mitigation, therefore, allows initiation of pumping for the project at the proposed project pumping rate, until drawdown trigger levels are reached at one or more monitoring locations throughout the valley (Table 3.2-7). Model predictions indicate that the trigger levels could be reached in as little as 1.2 years; however, some conservative assumptions that are built into the model may extend this pumping period considerably longer, if actual decreases in the groundwater level occur more slowly than predicted. The trigger points have been established using the model to prevent a greater than 10% decrease in flows to Little Lake from ever occurring. Triggers are also further described in the HMMP in Appendix C4. Monitoring should occur monthly for at least three years, with results reported to the County within 2 weeks of data collection. After three years, if water levels are decreasing more slowly than predicted, the applicant can petition the County to reduce the measurement frequency to quarterly.

Data collection in the first few months to years would lead to a better understanding of the relationship between pumping at Hay Ranch and groundwater table drawdown throughout Rose Valley and at Little Lake. Pumping may continue as long as the project does not result in a significant decrease in groundwater available at Little Lake.

The types of data that would be collected to better understand and estimate sustained pumping rates after one year are fully described in the HMMP provided in Appendix C4. Within approximately 1 year of initiation of pumping, or less if trigger levels are reached sooner, the groundwater flow model should be recalibrated to the observed drawdown in groundwater levels, to allow for more accurate estimation of how long the pumping can continue without exceeding drawdown trigger levels and causing a significant reduction in water available to Little Lake, the springs, and wetlands. A qualified person approved by Inyo County Water Department and funded by the applicant would evaluate the results of the first year of data collection, would recalibrate the model, and working with the Inyo County Water Department and the applicant, and would estimate the duration of pumping that would keep impacts below the defined trigger levels. Recalibration of the model would also be necessary later, if pumping continues significantly longer than 1.2 years, as needed and appropriate to help understand the timing and magnitude of future drawdown of groundwater levels throughout the valley.

Implementation of mitigation measure Hydrology-3 along with Hydrology-4 would reduce potentially significant impacts to less than significant levels.

> **Hydrology-3:** Monitoring shall occur at a frequency that is sufficient to detect important changes and trends in water levels. Monitoring shall occur monthly, at a minimum, at all monitoring points, following project start-up. The data shall be collected and analyzed by a qualified person approved by Inyo County Water Department and provided by the applicant. Monitoring reports shall be prepared by the applicant and submitted to Inyo County Water Department within 20 days of data collection. After two years, monitoring shall occur quarterly. Reports shall also be provided to a designated recipient at Little Lake Ranch, Inc. A complete list of monitoring locations, parameters, and schedule is presented in Appendix C4, Tables C4-1 and C4-2. Hydrologic monitoring locations are shown on Figure C4-2, in Appendix C4. Two new monitoring well clusters, each with three wells with screened intervals at three different depths, located approximately 700 feet south of the Hay Ranch North Wells, and 700 feet south of the South Well, respectively, shall be installed by the project applicant, and as approved by the Inyo County Water Department. An additional new water table monitoring well shall be installed by the applicant and as approved by Inyo County Water Department,

Table 3.2-7: Drawdown Trigger Levels (in feet)

Project Elapsed Time, years	Dunmovin Area well	Pumice Mine well	Hay Ranch Observa tion well	Coso Ranch North well	Coso Junction #1 well	Navy G-36 well	Navy Lego well	Red Hill Cinder Road well	Navy 18-28 well	Little Lake Ranch North well
	Distance from Hay Ranch South Well (feet)									
	9,000	***6,100***	***1,300***	***9,700***	***10,900***	***26,000***	***27,300***	***32,000***	***38,000***	***42,600***
0.25	<0.2	0.5	3.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
0.5	0.3	1.3	4.7	0.4	0.3	<0.2	<0.2	<0.2	<0.2	<0.2
0.75	0.7	3.3	8.1	0.9	0.7	<0.2	<0.2	0.2	<0.2	<0.2
1	1.1	5.3	11.5	1.4	1.2	<0.2	<0.2	0.2	<0.2	<0.2
1.2	1.5	6.9	13.2	1.8	1.5	0.2	0.2	0.3	<0.2	<0.2
1.25	1.6	7.1	11.8	1.9	1.6	0.2	0.2	0.3	<0.2	<0.2
1.5	1.9	7	7.9	2.1	1.8	0.2	0.2	0.3	<0.2	<0.2
1.75	2.1	6.5	6.9	2.3	2	0.3	0.3	0.3	<0.2	<0.2
2	2.3	6	6.2	2.4	2.1	0.3	0.3	0.4	<0.2	<0.2
3	2.7	4.8	4.8	2.5	2.2	0.5	0.4	0.4	<0.2	0.2
4	2.8	4.1	4	2.5	2.2	0.6	0.6	0.5	0.2	0.3
5	2.7	3.6	3.5	2.4	2.2	0.7	0.7	0.6	0.3	0.3
Maximum Acceptable Drawdown (in feet)	2.8	7.2	13	2.5	2.3	1.1	1.1	0.7	1	0.4
Time to Max drawdown (years since pumping began)	4	1.3	1.2	3	3.5	14.5	15	12	22	13

NOTES

1) For any wells where predicted drawdown is less than or equal to 0.25 feet, actions related to these trigger points shall not be enforced, unless the drawdown seen in these wells is greater than 0.25 feet. Drawdown values of <0.25 feet are difficult to accurately detect.

2) Based on current groundwater flow model results, these maximum drawdown values listed above result from pumping the Hay Ranch production wells at design rates for 1.2 years, with specific yield values of 10%. These maximum acceptable drawdowns can occur several years after pumping at Hay Ranch ceases.

approximately midway between Coso Junction and the Cinder Road Red Hill well, to provide additional monitoring capability in this area.

The monitoring program also includes reassessment of model-predicted impacts and recalibration of the groundwater model by a qualified person approved by the Inyo Count Water Department, and provided by the applicant. After a period of one year of pumping, observed groundwater level changes shall be compared with predicted groundwater level changes in order to assess the accuracy of the model-predicted drawdown. If the observed water level changes at two or more of the selected monitoring points differ from predicted values (trigger levels) at those locations by at least 0.25 feet at any point in time, or a maximum acceptable drawdown is reached at a designated monitoring point, or as judged appropriate by Inyo County Water Department, the model shall be re-calibrated and the predicted impacts to groundwater levels re-forecast with the re-calibrated model. If the model results change with recalibration, the mitigation strategy shall be updated in response to new forecasts of potential impacts to groundwater, potentially including reducing the duration or rate of pumping, or other mitigation measures as described in the HMMP. Additional re-calibration is expected to be needed after one year, as monitoring continues and water level changes are detected farther down Rose Valley. Additional re-calibration of the model shall be conducted as appropriate following the criteria outlined above (i.e., if the predicted water level in two or more wells differs from observed water level drawdown by at least 0.25 feet or more, or one or more maximum acceptable drawdown levels in wells all across the valley are exceeded).

Because surface water bodies at the Little Lake Ranch property are likely sensitive to changes in groundwater elevation and groundwater flow rate, the monitoring plan also identifies trigger levels that indicate when a significant impact (defined as a substantial reduction in water to Little Lake) will likely occur unless mitigation measures are implemented to reduce the pumping rate and/or duration of pumping. The plan includes the implementation of mitigation measures (namely, Hydrology-2 and Hydrology-4) to reduce any potentially significant impacts to less than significant levels.

Hydrology-4: The applicant shall be allowed to pump the project at the full proposed pumping rate until a time when and if the predicted groundwater drawdown trigger levels are exceeded at two or more of the designated Rose Valley monitoring points by at least 0.25 feet, or if a maximum acceptable drawdown level is exceeded in any monitoring point.

During the first year, a qualified person, approved by Inyo County Water Department and provided by the applicant, shall conduct the studies described in Hydrology-1 and Appendix C4 of this EIR in order to recalibrate the groundwater model to the early groundwater data. The groundwater model shall be recalibrated in order to more accurately understand the relationship between groundwater pumping, reduction in groundwater elevations across the valley, and availability of water at Little Lake. Pumping rates and duration of pumping shall be determined based on the results of the model and the observed water table drawdown.. At no time shall projected results of pumping result in a greater than 10% decrease in groundwater inflow to Little Lake (estimated to be equivalent to a 0.3-foot drawdown in groundwater head at the northern end of Little Lake) unless new data collected in the vicinity of Little Lake indicates that a larger decrease of head would not result in a greater than 10% decrease in groundwater inflow to Little Lake or substantially deplete the water availability to the springs and wetlands (as defined in the Hydrologic Mitigation Monitoring Plan in Appendix C4 of this EIR).

The revised pumping rate and duration shall be approved by the Inyo County Water Department. The recalibration shall occur within one year after project startup to ensure adequate time is available to make adjustments to the pumping schedule if necessary, to ensure significant impacts do not occur. The model shall be calibrated to the new drawdown data collected since project startup. Based on the results of the recalibrated model, a revised schedule for pumping and revised trigger levels shall be determined that will not be expected to cause a greater than 10% decrease in groundwater inflow to Little Lake. A revised plan for pumping rate and/or duration of pumping shall be submitted with full documentation to the Inyo County Water Department by the end of the 1st year of pumping. Pumping can continue as long as trigger levels in designated monitoring points that prevent a significant impact are not exceeded, and other signs of substantial impact on surface water bodies (Little Lake, springs, and wetlands) are not observed, as determined by a qualified person approved by Inyo County Water Department provided by the applicant.

An alternative option to minimize impacts to Little Lake could include pumping for one or more years at full scale and model recalibration as prescribed above; however, then reducing pumping to a lesser degree and/or allowing pumping for a longer period of time along with implementing a groundwater diversion plan at Little Lake. The diversion system would include additional pumping from an existing well at the Little Lake Ranch property, if feasible, or construction of a new well. Water would be piped from the well location along existing unpaved roads to the lake where it would be discharged. Water would be withdrawn at the minimum rate necessary to sustain water availability to Little Lake and the lower pond areas. The pumping amount and duration for a water diversion at Little Lake would be determined by a qualified person approved by the Inyo Count Water Department, and provided by the applicant, based on the recalibrated model. The diversion plan is further described in Appendix C4. Diversion would only be effective and implementable to minimize effects to less than significant levels if it was:

- Feasible given the availability of water at Little Lake and would not result in impacts to existing springs (e.g., Coso Spring)

- Agreed upon with Little Lake Ranch and the applicant
- Funded by the applicant
- Required for a reasonable timeframe (i.e., 20 years) that ensured accountability and funding by the applicant to mitigate all effects

If any of the above criteria are not met, then pumping would be scaled back or terminated based on model recalibration as previously described. If determined feasible, the applicant shall use biological and archaeological monitors during all ground disturbance activities associated with the construction of the augmentation plan components. The applicant shall also be responsible for obtaining any required permits for the diversion plan at the time that it is designed and implemented.

Depending on the permeability of lake bed sediments (which is currently unknown), groundwater diversion on the property may slightly raise or lower the groundwater table beneath Little Lake. If more permeable sediments are present, more water will seep back into the aquifer through the lake bottom. If less permeable sediments are present, less groundwater will seep back into the aquifer beneath the lake and drawdown may increase over and above the drawdown created by Hay Ranch well operation. However, if less groundwater seeps back into the aquifer, less groundwater will need to be diverted to maintain the lake level. Flow diversion would not likely impair spring or siphon well flow because most of the groundwater would be returned to the aquifer or pond system by way of seepage from the lake bottom or infiltration losses from the outfall stream.

Diversion by pumping groundwater from one of the Little Lake Ranch wells into the lake reportedly has been conducted in the past; however, details of previous water diversion efforts were not available for review. The modeling indicated that pumping a well near the south end of the lake or farther south on the Little Lake Ranch property would minimize impacts on Little Lake. The currently unused Little Lake Hotel well was reportedly artesian indicating that it is completed below the groundwater table in a confined groundwater-bearing zone. Extraction from the Hotel well or from the depth interval screened by that well, south of Little Lake, would minimize impacts to the lake and shallow groundwater.

Use of a biological and archaeological monitor during construction of the augmentation plan would minimize potential impacts to biological and cultural resources. Use of a monitor would allow sensitive resources to be avoided. Impacts to biology and cultural resources would likely be less than significant due to the scale of the project (which would likely include a 20-foot long pipeline) and the fact that access and construction would occur in previously disturbed areas. The applicant would also arrange for the appropriate electrical upgrades, and fund the cost of supplying and maintaining the electrical power, well, and pump equipment, if needed, at Little Lake Ranch to support pumping. The timing of the implementation of the proposed temporary augmentation plan is defined and would be determined through implementation of the HMMP prescribed in mitigation measure Hydrology-1.

It should also be noted that the applicant is subject to all regulations as stated in the Inyo County Code, Chapter 18.77.045 and 18.77.055, which allows for the CUP to be challenged if at any time if conditions of the permit are not being implemented or pumping is proven to be “causing unreasonable effect on the overall economy or environment of Inyo County.” The permit could be modified or revoked as a result. Conditions of the code also help to minimize the potential for potentially significant impacts associate with the project. The final decision on any modifications to the CUP shall be in compliance with the Inyo County Code.

Decommissioning

Decommissioning would involve removing above ground project components, including the tanks and the equipment on the Hay Ranch property, and abandoning the underground pipeline in-place. Pumping of the Hay Ranch wells would terminate and no more water would be transported out of the basin as part of the proposed project.

Impacts to groundwater levels from decommissioning would cease; however, there is a time lag for drawdown caused by the previous operations of up to 30 years or more after pumping has ceased. Groundwater levels would begin rising back to predevelopment levels following the time lag. Groundwater levels are expected to continue to decrease for a period of time following cessation of project pumping, as previously described, in areas in the southern part of the valley. Mitigation measure Hydrology-4 requires monitoring during pumping to ensure that trigger levels for groundwater drawdown in all monitoring wells will not be exceeded even after pumping ceases. Impacts would be less than significant with implementation of this measure.

Potential Impact 3.2-3: The potential to cause a significant alteration in the temperature or water levels of the surface features at Coso Hot Springs through injection of additional water into the Coso geothermal reservoir

Overview of Impact

Construction of the proposed project would have no impact on the Coso Hot Springs. Project operation has the potential to impact the hot springs. The Coso Hot Springs have been monitored closely since the beginning of geothermal production in 1988. On-going numerical modeling has been performed to understand the relationship between changes in Coso Hot Springs and geothermal development. Observed variations in hot springs may or may not be a result of the existing geothermal operations, although strong evidence supports a relationship where reduced pressure in the geothermal field creates an increase in the size of the steam cap. This increased steam cap is believed to have influenced the hot springs, making them initially increase in water level and temperature right after geothermal activity commenced in the late 1980s. The proposed project involves injecting water into the system, which theoretically could counter the pressure differential and result in a decrease or stabilization of the steam-dominated portion of the reservoir and a decrease (or stabilization) in water level and temperature in the hot springs. These changes could make the hot springs closer to their pre-geothermal development condition.

The geothermal system is highly complex and also influenced by many natural factors. Negative changes to the hot springs are not expected as a result of the proposed project. The monitoring program established at the beginning of the development of the Coso geothermal resource and specified in the original 1979 MOA between CLNAWS, the State Historic Preservation Officer, and the Advisory Council on Historic Preservation records physical changes in the Hot Springs. This existing, ongoing monitoring program provides a safeguard for the Hot Springs by providing a long history of the physical conditions at the Hot Springs before the project and a record of the physical conditions through the life of the project.

Construction

Construction would have no hydrologic impacts on the Coso Hot Springs. Construction would occur on the surface, 2.5 miles from the Coso Hot Springs and would not involve the geothermal reservoir or result in impacts to the reservoir.

Operation and Maintenance

Project operation includes injection of groundwater into the existing geothermal field in the Coso range at a rate of approximately 4,839 acre-ft/yr (or 3,000 gpm of water or 1,500 kph) into the reservoir. The water would be added to the existing injection system, which is designed to distribute the water at multiple locations within the reservoir in order to maximize the production from the injection and minimize cooling or ponding of injected water. Evaluation of the effectiveness of the injection program would continue throughout the project and adjustments would be made as additional information is gathered.

Injection may or may not have an impact on the nearby Coso Hot Springs. The hot springs are made up of a series of pools located 2.5 miles from the proposed injection site. The hot springs are believed to be created by brine and steam that condenses at it reaches the surface, which travels along the Coso Wash Fault. The springs are a site of Native American interest and included in the National Register of Historic Places (refer to Section 3.5 Cultural Resource). Concerns regarding the potential effects of the project on the Coso Hot Springs include potential changes to the temperature, water levels or appearance of the Coso Hot Springs, and related surface manifestations of the Coso geothermal system as a result of the proposed injection into the geothermal reservoir.

The Coso Hot Springs have been monitored continuously since geothermal production began in 1988. The monitoring results suggest that water temperatures and average water levels in Coso Hot Springs South Pool have increased over time. South Pool water levels stabilized rapidly; however, temperatures increased until 1993, then decreased in 2002 (Figure 3.2-18, Geologica 2007).

Elsewhere in the Coso Hot Springs area, steam manifestations have both increased (Pipeline and Fault Line fumaroles) and decreased (Devil's Kitchen). Water levels in wells east of the hot springs have decreased in area, but remained steady after the initial change (Coso #1), while wells west of the Coso Hot Springs (4P and 37-4TCH) have increased in area following the initial change. Many of the changes since the onset of geothermal reservoir production have been abrupt and erratic, whereas reservoir production has been relatively steady. Changes in chemistry of the monitored surface manifestations are variable, but generally reflect a decrease in brine component of the water making up the surface manifestation relative to the steam or steam condensate component.

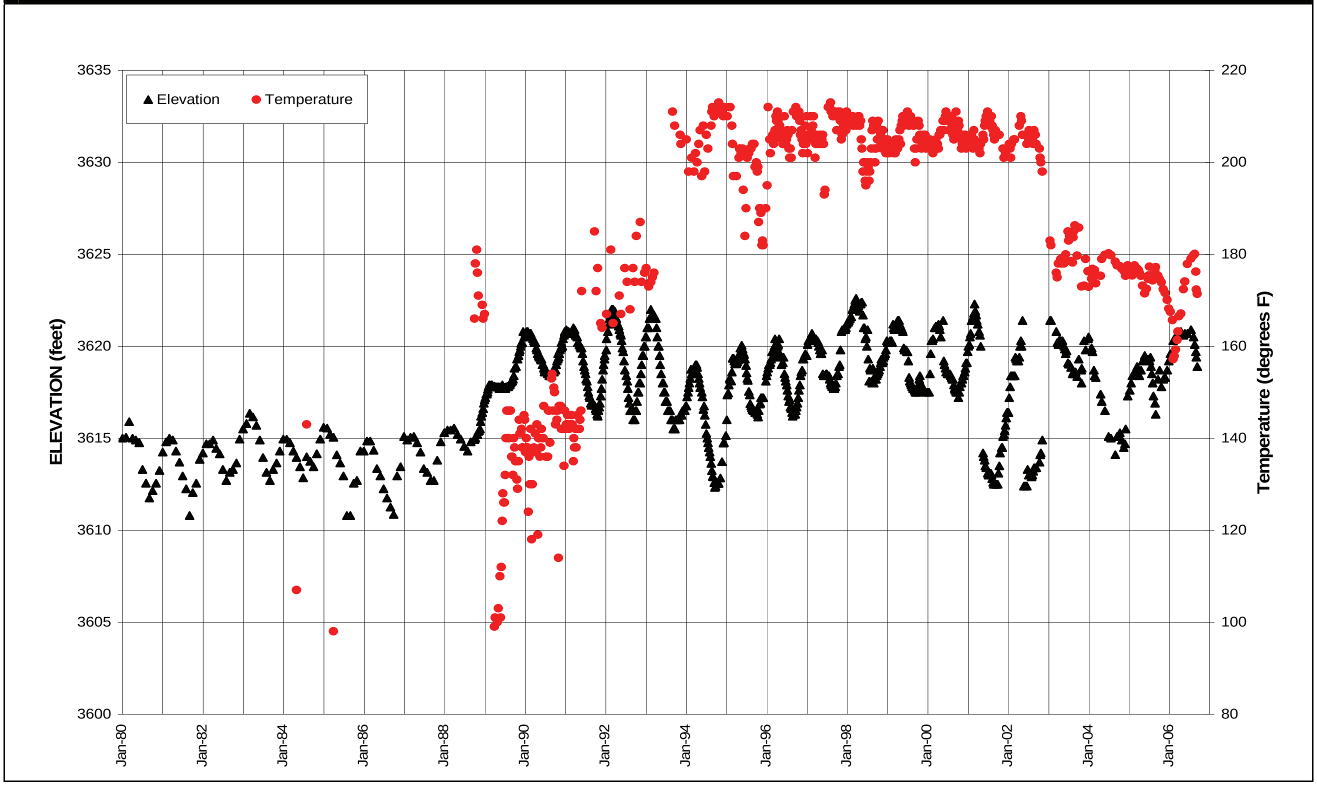
Steam flows in wells, water levels in wells, and surface manifestations reflect seasonal (and sometimes diurnal) variations (Geologica 2007). Changes to surface manifestations do not appear to correlate temporally with available injection data. Nor do they correlate with changes in rainfall or seismic events (Geologica 2005; 2006; 2007).

Innovative Technical Solutions, Inc. (ITSI) prepared an independent analysis of the hot springs in April 2007 for the Geothermal Program Office of the US Navy. The purpose of the study was to investigate and model a possible connection between geothermal production and changes observed at the Coso Hot Springs since 1988. The report prepared by ITSI in 2007 suggests that there is a correlation between the increase in the steam zone within the reservoir and increased steam flow up the Coso Wash Fault. Increases in temperatures and water levels in the South Pool are related to increased steam discharge based on numerical simulation. Changes in chemistry (Geologica 2005; 2006; 2007), and stable isotopes (Adams 2004) also suggest increased geothermal reservoir steam discharge at the surface.

There has been extensive study of the relationship of the Coso Hot Springs to the geothermal reservoir and local groundwater, particularly studies initiated by the Navy (including Erskine and Lofgren 1989, Guler, 2002, Williams, 2004 and ITSI 2007). Most studies indicate that there is no dilute low-temperature groundwater overlying the reservoir (Adams et al. 2000). Although there is some evidence of geothermal discharge to groundwater systems south to Indian Wells Valley and west towards Rose valley (Williams 2004), the relationship of the developed portion of the geothermal system to surrounding groundwater appears to be limited by no-flow boundaries such as the Coso Wash Fault and a mineralogical cap (ITSI 2007).

Stable isotopic signatures of Coso Geothermal fluids have been evaluated for purposes of identifying the source of the geothermal fluids (Figure 3.2-19). The High Sierras (Fournier and Thompson 1980) and the Coso Range (Williams and McKibben 1990) have been identified. Isotopic signatures of fluid samples from the surface studies also suggest that waters from the surface manifestations are affected by boiling or have a slightly different source.

Figure 3.2-18: Temperature and Water Level Variations in South Pool Geothermal Production began in October 1987



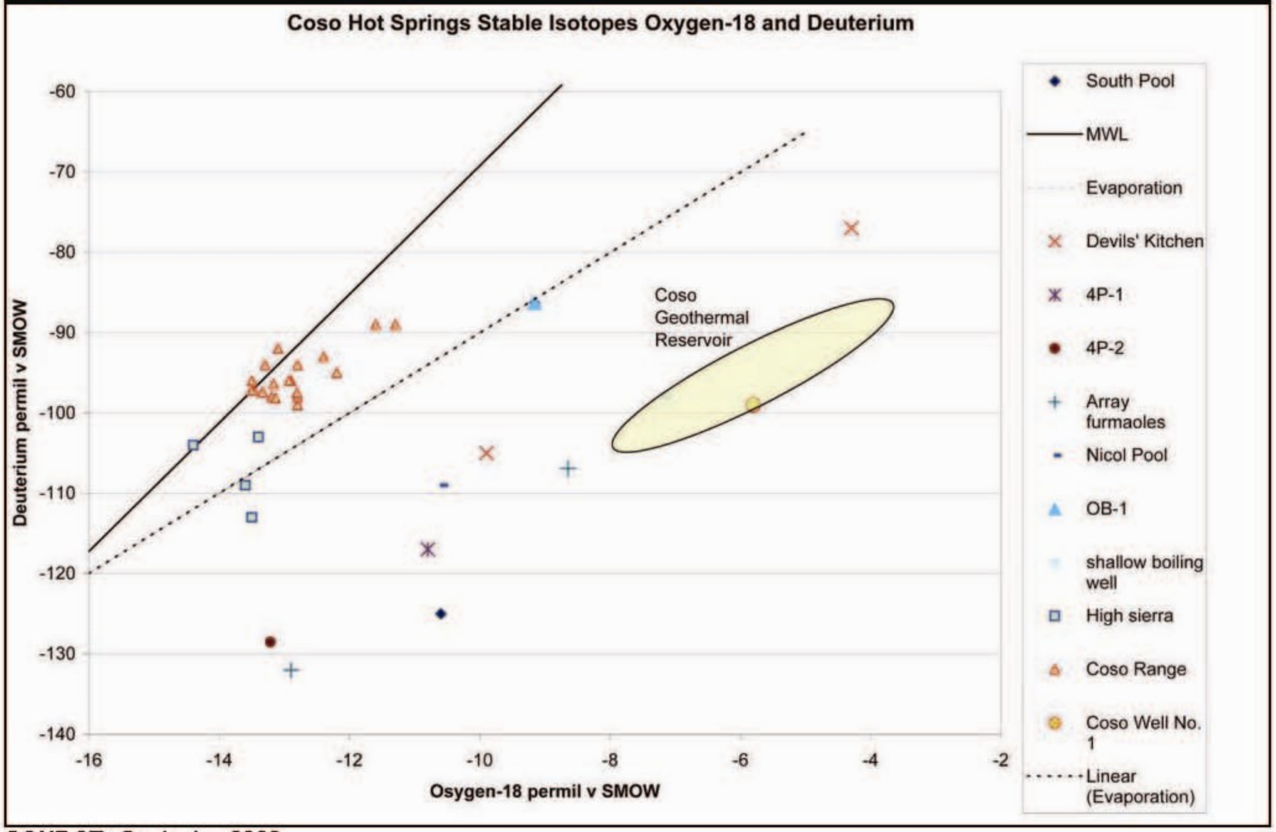
SOURCE: Geologica 2008

A steam zone is believed to have developed in the reservoir as a result of pressure decline related to a net mass deficit from the geothermal reservoir (ITSI 2007). The proposed project would reduce the net mass deficit by approximately 1,500 kph from 50 percent to less than 20 percent, thereby slowing or reducing this change. Projected overall reservoir behavior based on reservoir modeling by Coso (personal communication 2008) indicates that production declines would slow, suggesting pressure support, and enthalpy would stabilize or decrease, suggesting the impact of injection related to the proposed project on the geothermal reservoir is most likely to reduce the growth of the steam zone within the reservoir.

Although changes in surface manifestations described above correlate temporally with the onset of geothermal development, the direct relationship between development of the resource at Coso and the variation in the physio-chemical character of the Coso Hot Springs such as South Pool is less clear. ITSI (2007) suggests that the development of the steam zone has produced increase steam discharge along the Coso Wash Fault and the rise in water levels and temperatures in South Pool are related to increased steam discharge to the surface. This correlation is not unreasonable and has been suggested for correlations between changes in surface manifestations and development of other geothermal fields (Sorey 2000). However, the changes in South Pool have occurred in abrupt steps with some reversals (see Figure 3.2-3b) and the growth of the vapor zone in the reservoir has been more gradual than changes in South Pool.

Geothermal development may or may not have produced observed changes to the Coso Hot Springs. If the observed changes at Coso Hot Springs are related to an increasing steam zone within the reservoir related to geothermal development, the proposed project would likely reduce or reverse those changes by reducing the development of the steam zone.

Figure 3.2-19: Coso Hot Springs Stable Isotopes Oxygen-18 and Deuterium



SOURCE: Geologica 2008

Impacts to the surface manifestations of the Coso geothermal system related to the project would be minimal because:

1) Connection to the reservoir appears to be indirect
2) The proposed project would increase liquid injection and decrease the net withdrawal related to geothermal development thereby minimizing the pressure decrease-related development (or possibly reversing) of a vapor-dominated zone within the reservoir. By minimizing changes in the reservoir from the existing geothermal project, changes tothe surface manifestations that may be connected to the reservoir would be minimized

Therefore, depending on the level of connection, this project will act to minimize additional changes because the goal of the project is to support reservoir pressure and therefore the project is unlikely to create changes in surface manifestations.
Potential impacts to the hot springs from the original Coso Geothermal Power Development fall under the existing 1979 MOA between CLNAWS, the SHPO, and the Advisory Council on Historic Preservation (refer to Appendix E). This MOA addresses development of geothermal resources on Navy fee-acquired land within the Coso known geothermal resource area (KGRA). The proposed project is part of the development of the Coso KGRA; therefore, it falls under this MOA. The MOA Includes consultation and although this project is not expected to have a significant impact on Coso Hot Springs, the existing monitoring program provides both a long baseline of physical conditions as well as monitoring over the life of the project. This existing monitoring program includes acquisition of appropriate data to monitor changes to the Hot Springs over the life of the

springs. With implementation of measures in the MOA, the project is not expected to have a significant impact on Coso Hot Springs. No mitigation for the proposed project is needed. The 1979 MOA is included in Appendix E to this EIR.

Decommissioning

Decommissioning would involve removal of project equipment on public land and abandonment of the pipeline in place. Equipment on the Hay Ranch property would be removed and disposed of, stored, or recycled. Injection would cease just prior to the decommissioning phase. Some changes may occur to Coso Hot Springs after project decommissioning; however, changes would be a result of restoration of natural conditions and would therefore not be significant. Decommissioning would have less than significant impacts on the Coso Hot Springs.

Potential Impact 3.2-4: The potential to substantially alter the existing drainage pattern in the project area in a manner which would result in substantial erosion or siltation on- or off-site

Overview of Impacts

Grading, foundation work, installation of drainage structures, and surface activities would result in temporary disturbance of approximately 59.5 acres of native vegetation and soils, and could result soil erosion and siltation of on and off-site drainages. These potential erosional impacts would be mitigated to less than significant levels through implementation of a SWPPP and implementation of an erosion control plan. Impacts would be less than significant. Project operation would have less than significant impacts on existing drainages and erosion or siltation. Some water discharge may be performed for pipeline maintenance, but it would be minimal and would not cause substantial siltation of existing waterways.

Construction

Wells. Wells would require the installation of down hole pumps and equipment and would have no potential to substantially alter existing drainage patterns on the project site that could result in erosion or siltation. Installation of the down hole pumps would not require any ground disturbance.

Lift Pump Station, Substation and Associated Facilities, and Tanks. Construction of these components would require about 6 acres of ground disturbance. With the exception of the 1.5 million gallon high point tank, all other facilities would be constructed on the Hay Ranch property. Drainage on the Hay Ranch property is to the south due to the gentle slope of the property in that direction. Construction would not change the existing drainage pattern such that substantial erosion or siltation would occur off-site.

Any exposed soils remaining after the construction of the station would be revegetated in accordance with COC's approved revegetation plan to minimize soil erosion. The lift pump station area would be finish-graded to provide for drainage to the southeast (the direction of natural slope on the parcel). A SWPPP would be implemented for the entire project as required by law to avoid erosion impacts due to drainage. Implementation of the mitigation measure Geology-1, which requires an erosion control plan would also reduce potential impacts to less than significant levels.

Pipeline. Construction of the pipeline route would require approximately 53.5 acres of ground disturbance. Grading would be minimized, particularly in the steeper areas near the high point tank, by constructing the right-of-way perpendicular to the contours. At the completion of pipeline construction, the right-of-way would be restored by finish grading with installation of water bars, and application of erosion protection in accordance with COC's approved revegetation plan to minimize effects to drainage. All fill slopes would receive erosion protection by redistribution of topsoil and application of a standard desert seed mixture at a rate of 25 pounds per acre. There are no perennial drainages in the vicinity of the pipeline route.

Operation and Maintenance

Wells, Lift Pump Station, Substation and Associated Facilities, and Tanks. These facilities would not alter drainage in the project area that could lead to substantial siltation off-site. These facilities would add about 3 acres of impervious surface. Water runoff would follow natural drainage patterns and would not result in substantial erosion of soil. The high point tank includes an overflow drain, which would be directed to an existing drainage. Soil erosion may occur at this point, depending on the quantity of water that could be released from the tank. To minimize soil erosion at either tank from periodic water releases, mitigation measure Geology-2 would be implemented, which requires stabilizing tank outlets with rip rap to minimize soil loss and sedimentation.

The tanks have sensors and alarm systems that are manned at the power plant 24 hours per day to minimize overflow and to identify emergency situations or failures. Catastrophic failure of either tank could cause soil erosion, particularly at the high point tank, which is larger and located on a hill. The potential for catastrophic failure is low and the impact is considered less than significant.

Pipeline. Maintenance of the pipeline may require some small discharges of water from air release valves along the pipeline. Erosion and sedimentation could occur from drainage of the pipeline for maintenance. These discharges would be small quantities (tens of gallons) of water directed towards the natural drainage adjacent to the road. If maintenance requires excavating portions of the pipeline, mitigation measure Geology-1 would be implemented to minimize erosion to less than significant levels.

Decommissioning

Decommissioning would involve removing or abandoning equipment in place. Minimal soil disturbance would be involved with the project decommissioning to remove foundations. The ground would be revegetated according to COC’s approved revegetation plan. Mitigation measure Geology-1 would also be implemented. The proposed buried pipeline would be abandoned in place. Impacts would be less than significant with the appropriate measures.

Potential Impact 3.2-5: The potential to cause substantial flooding that could result in damage to life or property

Overview of Impacts

The proposed project would not cause flooding from construction, nor would operation result in a significant potential to cause or be damaged by floods. Impacts related to flooding and flooding hazards are less than significant.

Construction

Construction would not cause substantial flooding. Some water would be used for dust suppression; however only small quantities would be applied to disturbed surfaces. Flooding would not occur.

Operation

Haiwee Creek runs south along the east side of US Highway 395, portions of which are identified as a Zone A Flood Zone. None of the structures of the proposed project are within the 100-year flood hazard area as mapped on the federal Flood Hazard Boundary Map or the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map No. 060073 1925B, dated September 4, 1985. If the creek flooded greater than the 100-year event as mapped by the FEMA projections, portions of the Hay Ranch property could experience minor flooding. The probability of this magnitude storm event occurring is so remote as to be less than significant. There are no inhabited structures or residences on the Hay Ranch site, nor along the 9 mile pipeline route.

The Hay Ranch wells are at elevation 3,437 feet amsl and the south spillway of Haiwee Reservoir is at an elevation of 3,760 feet amsl. The reservoir holds approximately 28,000 acre-feet of water. The dam is located approximately 4 miles north of the Hay Ranch property and the terrain from the dam to Hay Ranch is a relatively broad, open plain. If the dam suffered catastrophic failure, floodwaters would inundate the substation and nearby pipeline corridor, and damage structures as far away as Coso Junction. Therefore, the substation and portions of the pipeline corridor could suffer major flood damage. The substation would immediately become inoperable and pose no threat to workers or nearby residences or businesses. No element of the proposed project would lead to increased probability of a catastrophic failure of Haiwee Dam, and, the probability of a catastrophic failure is so remote as to be considered less than significant.

The project includes two water storage tanks, one holding 150,000 gallons and the other holding 1,000,000 gallons. Failure of these tanks would cause localized ponding on the Hay Ranch property and in the region of the high point tank. The tanks are designed to prevent catastrophic failure, including equipment that detects water level and leaks. The likelihood of catastrophic failure of the tanks is so remote that it is considered less than significant. Leakage of the pipeline could also cause some localized flooding; however, equipment would monitor pressures in the pipeline and regular inspection and maintenance would minimize the chances of pipeline failure that could result in localized flooding.

Decommissioning

Decommissioning would involve removal of project equipment on public land and abandonment of the pipeline in place. Decommissioning would minimize the potential for localized flooding since the project would no longer pump, store, or deliver water. There would be no flooding related impacts from project decommissioning.

Potential Impact 3.2-6: The potential to cause a violation of water quality requirements or otherwise degrade existing water quality in the area or impact drinking water and drinking water supplies

Overview of Impacts

Substantial withdrawals of water could potentially cause changes in groundwater flowpaths, such that the source of water at a particular well could be from a different area with a different water quality. However, given the scale of the area, it appears unlikely that changes in groundwater flow paths will be far-ranging enough to cause significant changes in the quality of groundwater. No significant impacts to surface water or groundwater quality are expected during construction or as a result of operation of the project.

Construction

Construction is not anticipated to have any impact to groundwater or surface water quality. The groundwater table is located more than 200 feet below ground surface along the pipeline alignment; spills or releases from construction equipment are unlikely to migrate down to the water table in sufficient volume as to impact groundwater quality. No perennial surface water bodies are located within or down gradient of the construction and therefore there impacts to surface water quality from construction are unlikely.

Operation and Maintenance

Operation of the proposed project is unlikely to have any significant impact on groundwater or surface water quality. The groundwater extracted by the Hay Ranch wells would primarily come from drainage of saturated soil pore space in the recent alluvial sediment deposits near the wells and to a lesser extent, groundwater inflow from Owens Valley and mountain front precipitation recharge in the Sierra Nevada range.

Groundwater flowing towards Little Lake Gap, currently, and after project startup, primarily comes from mountain front precipitation recharge entering the basin at locations downgradient (south) of the Hay Ranch with a smaller component of groundwater flowing downgradient (southward) within the valley aquifer. The mountain front recharge has good water quality (total dissolved solids <500 mg/L, see section 3.2.3. The valley aquifer water is higher in dissolved solids relative to mountain front recharge (total dissolved solids > 500 mg/L). Operation of the Hay Ranch project would have no effect on the chemical character of Sierra Nevada mountain front recharge; consequently, the project is unlikely to impact the quality of groundwater flowing towards Little Lake Gap and as seen in the surface manifestions (i.e., springs, siphon wells, Little Lake, and surrounding ponds and wetlands).

If the inflow to the southern part of Rose Valley from groundwater flowing downgradient within the valley aquifer is reduced, it is possible that the dissolved solids of groundwater flowing southward towards Little Lake Gap may be slightly reduced. By reducing the component of inflow of saline valley basin water relative to dilute mountain recharge water, the dissolved solids of groundwater in the Little Lake area may decrease, improving water quality. Effects to water dependent vegetation are addressed in Section 3.4 Biological Resources.

Decommissioning

Decommissioning would involve removal of project equipment on public land and abandonment of the pipeline in place. Decommissioning would not impact water quality since it would result in the restoration of natural conditions in the aquifer. The groundwater table is located more than 200 feet below ground surface along the pipeline alignment; spills or releases from demolition equipment are unlikely to migrate down to the water table in sufficient volume as to impact groundwater quality.

APPENDIX C

PUMP TEST RESULTS AND HYDROLOGIC DATA

APPENDIX C1
NOVEMBER/DECEMBER 2007 PUMPING TEST PROCEDURES, MONITORING DATA AND RESULTS

APPENDIX C1
NOVEMBER/DECEMBER 2007 PUMPING TEST PROCEDURES, MONITORING DATA, AND RESULTS

C1-1 Introduction

This appendix describes the procedures employed, equipment used, and monitoring results from a constant discharge aquifer pumping test conducted in Rose Valley, California in November and December 2007. The 14-day constant discharge aquifer test was conducted to further evaluate the potential impacts of extracting groundwater from the Hay Ranch property in north central Rose Valley for use in augmenting water supplies for the Coso Geothermal Project. Specifically, Coso Operating Company (COC) conducted an aquifer test to refine estimates of aquifer parameters (transmissivity, storage coefficient/specific yield, and vertical hydraulic conductivity or leakage) using transient data.

C1-2 Responsibilities

During the pumping test, COC's staff geologist and operations personnel were responsible for most field data gathering activities including installing electronic pressure transducers in selected wells, downloading electronic data on a daily basis for transmittal to Geologica , manually measuring water levels in observation wells, measuring the flow rate from the Davis well at Portuguese Bench, and recording the groundwater discharge rate from the pumped well. As a quality assurance measure, Geologica 's senior geologist/hydrogeologist visited the site at the start of the test on November 19, midway through the test on November 28, and on the last day of pumping on December 3, 2007 to observe test procedures. Geologica reviewed the pumping test data on a daily basis and recommended extending the test from the original planned 10-day constant rate pumping test to the final 14-day duration. COC engaged Howard Pump to place the test pump in the Hay Ranch South well and fuel the generator and maintain the equipment throughout the test. At the end of the test, Geologica analyzed the pumping test data to estimate aquifer parameters and to recalibrate a numerical groundwater flow model for Rose Valley (described in Appendix C-2 to this report).

C1-3 Aquifer Test Design and Procedures

The constant discharge pumping test comprised pumping the Hay Ranch South well for 14 days (from 3:59 p.m. on November 19 to 4 p.m. on December 3) followed by recovery monitoring for a period of approximately 7 days. The Hay Ranch South well was pumped at a constant rate of 1,925 gallons per minute (gpm) during the test. Background groundwater level and barometric pressure monitoring was initiated prior to the start of pumping in the Hay Ranch well to evaluate baseline conditions. The Davis's and COC staff measured the groundwater discharge rate from the Davis siphon well (aka the Davis spring) at Portuguese Bench using a bucket and stop watch periodically after the start of the pumping test. Pump test procedures generally followed the recommendations in the memo prepared by Geologica dated November 7, 2007 and are described below. Monitoring locations are shown on **Figure C1-1**.

C1-3.1 Test Well Setup and Monitoring

C1-3.1.1 Test Well Construction

The Hay Ranch South well is a former irrigation well constructed in 1974. The well was completed to a depth of 675 ft below ground surface (bgs). The 16-inch-diameter steel well casing has mill cut slots between 200 and 675 ft bgs but was gravel packed between ground surface and 675 ft bgs so is presumed to fully penetrate the Rose Valley alluvial aquifer. The South well reportedly has not been used since alfafa farming ceased, prior to COC's acquisition of the property. At the start of the pumping test on November 19, 2007, the depth to the groundwater table in the South well was 179 ft bgs.

C1-3.1.2 Test Pump

COC contracted with Howard Pump to install a temporary pump in the Hay Ranch South Well. Installation of the pump began the morning of November 19, 2007. The pump was set with the inlet bowls at a depth of 400 ft bgs. The line-shaft turbine pump was powered by a trailer mounted diesel engine with variable speed control. At the time of pump installation, a 100 pounds per square inch (psi) vented In Situ Mini-Troll electronic pressure transducer ("transducer") was installed approximately 145 ft below the initial groundwater table.

C1-3.1.3 Produced Water Discharge

Groundwater produced during the test was piped to an irrigation distribution system and discharged on the ground approximately ¼ mile south of the test well. A perforated pipe sprinkler system was used to distribute the water over the ground surface to reduce the potential for runoff, ponding, and/or soil erosion.

C1-3.1.4 Test Well Monitoring

COC initiated groundwater level monitoring in the test well using the In Situ data logging system at 12 noon on November 19, 2007. Water pressure, reflecting the height of the column of groundwater above the transducer, and water temperature were measured and recorded every 5 minutes until just before noon on December 6. COC staff made manual depth to water measurements in the well on November 15 and 19, 2007 using an electronic water level sounder. The pump contractor installed a flow meter/totalizer on the pump discharge line at the well head. COC operating department staff inspected the pump, generator, and discharge system four times each day (approximately every six hours) during the pumping portion of the test, and recorded flow rate and the flow totalizer reading in an operating log. A copy of the test well operating log is provided in **Table C1-1**.

C1-3.2 Observation Well Selection and Monitoring

The groundwater level monitoring program consisted of a combination of long term and short term monitoring conducted before, during, and after the pumping test depending on well access and operational constraints. COC utilized existing agriculture and drinking water supply wells owned by various parties including COC for pumping test monitoring; no new wells were constructed for this test. Most, but not all, of the wells monitored for the 2007 pumping test are currently out of service. In addition to intensive monitoring of the North well on the Hay Ranch property, which is located approximately ½ mile north of the test well, wells were selected throughout Rose Valley to maximize the data set available for analysis. **Table C1-2** summarizes the wells monitored, duration and frequency, and monitoring equipment utilized. Well locations are shown on **Figure C1-1**.

Monitored well characteristics are briefly summarized as follows:

- The Hay Ranch North well was drilled in 1971 and is 724 ft deep with slotted screen open from 120 ft bgs to the bottom of the hole. Due to its depth, it is believed to fully penetrate the Rose Valley alluvial aquifer. Reportedly, the well has not been used since the mid-1970's. COC installed a 30 psi unvented transducer and initiated a groundwater level monitoring program in the well on August 29, 2007 and made manual water level measurements periodically during the pumping test. COC installed a 5 psi vented transducer in the well on November 19, 2007 and began automatic water level monitoring every 15 minutes with the more sensitive transducer at noon that day continuing through December 10, 2007.
- The out of service Cal-Pumice (Pumice Mine) well located approximately 1-1/4 miles northwest of the test well, is 397 ft deep with casing perforations between 300 and 397 ft bgs. The Pumice Mine well penetrates the upper portion of the Rose Valley alluvial aquifer. COC installed a 5 psi vented transducer in the well and began monitoring water levels every 15 minutes beginning on November 14, 2007 continuing through December 10, 2007.
- COC monitored groundwater levels in two former irrigation wells, V816 and V817, owned by the Los Angeles Department of Water and Power (LADWP) located approximately 1.7 miles north of the test well. The wells are approximately 500 ft deep and open to the upper portion of the Rose Valley alluvial aquifer. COC installed a 5 psi vented transducer in well V816 on November 14, 2007 and manually measured depth to groundwater in both wells periodically between November 14 and December 5, 2007.
- COC monitored groundwater levels in the Coso Ranch North well located on the west side of highway 395 approximately 1.8 miles south of the test well. No well log was available for the well. Because it appears to have similar construction to the Coso Ranch South well which is 740 ft deep, it is assumed to fully penetrate the Rose Valley aquifer. The Coso Ranch North well is not used, however, the Coso Ranch South well is pumped several times a day to fill a water truck for the Pumice mine. The Coso Ranch South well is located approximately 1,900 ft south of the North well; however, pumping the South well did not appear to measurably affect groundwater levels in the North well. COC installed a 30 psi unvented transducer and initiated a groundwater level monitoring program in the well on August 29, 2007 and made manual water level measurements periodically during the pumping test. COC installed a 5 psi vented transducer in the well on November 14, 2007 and began automatic water level monitoring every 15 minutes with the more sensitive transducer at noon that day continuing through December 10, 2007.

- COC manually measured depth to groundwater in two unused wells, the Lego well and well G-36, located on Navy property approximately 5 miles southeast of the test well. Although the wells are believed to be less than 400 ft deep, no construction details were available for either well.
- COC monitored groundwater levels in the Navy 18-28 well located approximately 7.2 miles southeast of the test well. The 430 ft deep well screens interbedded deposits of sand, basalt, and volcanic ash/tuff in the upper portion of the Rose Valley aquifer. COC installed a 30 psi unvented transducer and initiated a groundwater level monitoring program in the well on October 12, 2007 and made manual water level measurements periodically during the pumping test. COC installed a 5 psi vented transducer in the well on November 14, 2007 and began automatic water level monitoring continuing through December 10, 2007.
- COC monitored the groundwater level in an unused well (Little Lake Ranch North well) located at the north end of the Little Lake Ranch property approximately 8 miles south of the test well. No construction information was available for this well. Judging from the shallow depth to groundwater at this location, approximately 40 ft, the well is screened in the top of the Rose Valley alluvial aquifer. COC installed a vented 30 psi transducer and began monitoring groundwater levels every 15 minutes beginning on November 19, 2007 continuing through December 10, 2007.

All wells with pressure transducers were also manually gauged. Manual water level measurement data are summarized in **Table C1-3**. Because unvented pressure transducers were used in the long term monitoring wells, barometric pressure was monitored using an In Situ BaroTroll pressure transducer.

C1-3.3 Davis Siphon Well Monitoring

The groundwater discharge rate from the Davis family siphon well at Portuguese Bench was monitored periodically during and after the pumping test. The siphon well is located approximately 100 ft behind the Davis's house and uphill from their pond. The siphon well consists of an approximately 10 ft deep dug well vault with a slotted casing extending an additional 10 ft bgs (approximately 20 ft total depth). A sealed 4-inch-diameter PVC pipe inserted below the water level in the slotted casing crosses the property from the siphon well to discharge at the pond on the east side of the house. The discharge end of the pipe is lower than the groundwater level in the siphon well so that when the pipe is primed (filled with water) it freely siphons water from the well to discharge in the pond. To assess whether pumping the Hay Ranch wells might impact well discharge on the Davis property, the discharge rate from the siphon was measured approximately daily between November 19 and December 10, 2007. The groundwater disharge rate was measured using a stop watch to measure the amount of time required to fill a plastic bucket from siphon line to the pond. Measurements were repeated 3 to 5 times at each daily reading and recorded in a field notebook. A summary of the discharge readings is provided in **Table C1-4**.

C1-3.4 Interferences and Data Corrections

Several factors or events complicated analysis of the pumping test monitoring data. These included:

- The Hay Ranch South Well was pumped for approximately 10 minutes beginning at 3:25 p.m. on November 19 but the pump shut down due to a voltage regulation issue. The problem was fixed and the pumping test restarted at 3:59 p.m. Because of the short duration and great distance to observation wells, this pumping and recovery incident did not appear to induce response in observations wells. The test well recovered to within 2 ft of the initial static level by the time the 14 day test was started.
- Pre-existing water level trends, notably falling groundwater levels were observed in the Cal-Pumice, LADWP V816, and V817 wells. Data from the Cal-Pumice, V816 and V817 wells could not be used for aquifer parameter evaluation because of the nearly 0.4 ft drop in groundwater elevation observed in these wells between November 14 and December 5, 2007. The cause of the groundwater elevation decline in these wells is unknown. Data obtained from the LADWP aqueduct operations website indicated that the water level in the Haiwee South reservoir located nearly 2.5 miles north of the V816 and V817 wells, rose nearly 4 feet during this time period. Water seepage from the reservoir is believed to recharge the Rose Valley alluvial aquifer north of the Hay Ranch property and would be expected to increase or remain the same as reservoir levels rise. Consequently, it does not appear that changes in groundwater level in the LADWP wells were directly related to reservoir seepage.
- Water level drawdown was observed in the Coso Junction Store Well #1 resulting from unmetered pumping of the Coso Junction Store Well #2 which is approximately 25 ft south of well #1. This included a period of approximately 10 hours when the #2 well pumped without stop because of a water main break near the well head. As a result, the Coso Junction Store Well #1 groundwater level observations could not be used for aquifer parameter estimation.
- Uncontrolled pumping of the Coso Junction #2 well may have caused as much as 0.1 ft of groundwater level drawdown in the Coso Ranch North well, which is the next closest nearby observation well. The Coso Ranch North well appeared to have recovered from this disturbance at about the time it started to respond to pumping in the Hay Ranch South well.
- Groundwater elevation fluctuations throughout the Rose Valley monitoring well network as a result of variations in barometric pressure. Barometric pressure fluctuated over a range of up to 0.43 pounds per square inch (psi) [equivalent to 1 foot of water] between November 19 and December 4 (see **Figure C1-2**). This induced groundwater elevation fluctuations that ranged in magnitude from 0.05 ft in the Little Lake Ranch North well to 0.83 ft in the Hay Ranch wells. Increasing barometric pressure can induce an increase in apparent depth to groundwater in observation wells (and conversely) but has no significant affect on groundwater levels within the aquifer. When possible, barometric pressure fluctuations were correlated with groundwater elevation fluctuations to estimate barometric correction efficiency factors for individual wells. A barometric correction was applied to the transducer data that involved adding the negative of the product of barometric efficiency and barometric pressure change between water level readings to the recorded water pressure change. Estimated barometric efficiencies

ranged from approximately 5% in the Little Lake Ranch North well to 83% in the Hay Ranch wells. The barometric correction could not be applied to wells that were only gauged manually (V817, G-36, or Lego) because there were insufficient water level data to develop a correlation. The barometric correction factors were not effective in removing all apparent barometric-related water level fluctuations apparently due to variations in the response to barometric pressure fluctuations.

C1-4 Pumping Test Results

This section discusses the results of the constant discharge aquifer test.

C1-4.1 Pumped Well Response

The Hay Ranch South well drew down approximately 107 ft from static during the pumping test indicating a specific well capacity of 18 gpm/ft of drawdown. This compares well with the value of 21 gpm/ft noted for the 24 hour pumping test conducted in this well in 2003 (GeoTrans, 2003). The well recovered to within 3 ft of the initial static level within 3 days of terminating pumping. A plot showing groundwater elevation versus time in the pumped well is shown on **Figure C1-3**.

C1-4.2 Observation Well Response

Groundwater elevation measured in the observation wells is graphically depicted on **Figure C1-4** for the LADWP wells, **Figure C1-5** for the Cal-Pumice well, **Figure C1-6** for the Hay Ranch North well, **Figure C1-7** for the Coso Ranch North well, **Figure C1-8** for the Coso Junction Store #1 well, **Figure C1-9** for the Lego and G-36 wells, **Figure C1-10** for well 18-28, and **Figure C1-11** for the Little Lake Ranch North well. Manual gauging data are depicted as discrete points on the water level plots; transducer data are represented with a continuous line.

As noted previously, groundwater elevation in the LADWP wells (V816 and V817) and Cal-Pumice well declined nearly 0.4 ft between November 14 and December 10, 2007 (**Figures C1-4** and **C1-5**). Because they are located 9,000 and 6,400 ft north of the test well, respectively (see **Figure C1-1**), and because the water level decline started before pumping started, it was not possible to determine whether pumping the Hay Ranch South well caused drawdown in these observation wells. Evaluation of groundwater elevation changes in the Cal-pumice well was additionally complicated by water level fluctuations in the well apparently caused by barometric pressure fluctuations that were of the same order of magnitude as drawdown at this location potentially caused by test well pumping.

The groundwater elevation in the Coso Ranch North and Hay Ranch North wells appeared to decline approximately 0.3 ft and 6 ft, respectively, as a result of test well pumping. Evaluation of this response to estimate aquifer parameters is discussed below.

The groundwater elevation in the G-36 well which is located approximately 5 miles southeast of the test well declined slightly (less than 0.05 ft) during the pumping test but did not recovery after pumping stopped (**Figure C1-9**). The water level in the Lego well (also located approximately 5 miles southeast of the test well) may have declined slightly but responded strongly to barometric pressure fluctuations, fluctuating nearly 0.3 ft as a result. Based on these observations, it appears unlikely that the test well pumping induced significant drawdown at this distance.

The groundwater elevation recorded in the Navy 18-28 well (**Figure C1-10**) increased by approximately 0.1 ft during the pumping test indicating no impact from pumping the Hay Ranch test well at this distance (more than 7 miles from the Hay Ranch). The groundwater elevation in the Little Lake Ranch North well (**Figure C1-11**) also increased very slightly (approximately 0.07 ft) during the pumping test indicating no response at this distance (8 miles south of Hay Ranch).

C1-4.3 Portuguese Bench Siphon Well Response

As shown on **Figure C1-12**, the discharge rate from the Davis' siphon well fluctuated around an average value of approximately 4.55 gpm between November 19 and December 3 but then decreased to slightly over 4.2 gpm after test well pumping terminated. The fluctuations in well discharge rate do not appear to be related to groundwater extraction at Hay Ranch or barometric pressure fluctuations (illustrated on **Figure C1-12**), but may relate to temperature/weather changes in the mountains west of the Davis property. Because the intake for the Davis well is located at an elevation approximately 600 ft higher than groundwater table elevations in Rose Valley, no response was expected.

C1-5 Estimated Aquifer Parameters

Geologica used standard graphical methods to evaluate aquifer properties. Plots were prepared of drawdown versus the logarithm of elapsed time (semi-log plots) for data from the Hay Ranch North and South wells, and the Coso Ranch North well as shown on **Figures C1-13** through **C1-15**, respectively. Additionally, a plot of logarithm of drawdown versus the logarithm of elapsed time (log-log plot) for the Hay Ranch North Well was developed as shown on **Figure C1-16**. The Cooper-Jacob Straight-Line Method (Dawson and Istok, 1991) was used to estimate aquifer transmissivity and storage coefficients using the semi-log data plots from the Hay Ranch South well and Coso Ranch North well. Transmissivity values estimated from early well response ranged from 6,630 to 19,400 ft^2/day in the Hay Ranch wells and 165,700 ft^2/day in the Coso Ranch North well (see Table C1-5). Storage coefficients estimated for the Hay Ranch North well and Coso Ranch North well were 0.00077 and 0.0014, respectively. Later well response exhibited decreasing rates of groundwater table drawdown with time indicative of vertical drainage. These are considered to be rough estimates because the Jacob-Cooper time constraint was not met for portions of the early time data and the analysis method is intended for confined aquifers.

Analysis of time drawdown data from the Hay Ranch North well using the Neuman (1975) delayed yield type-curves indicated an aquifer transmissivity of 14,750 ft^2/day and storage coefficient of 0.001. Assuming a saturated thickness of 600 ft, these results indicate a horizontal hydraulic conductivity of approximately 25 ft/day. The vertical hydraulic conductivity of the aquifer was estimated to be 0.01 ft/day using a Neuman

“Beta” coefficient of 0.01 from the type curve match and an aquifer thickness of 600 ft. The time-drawdown data from the Hay Ranch North well are considered to provide the best indication of aquifer response because drawdown in the well substantially exceeded interferences from barometric pressure and other wells pumping. The Neuman delayed yield type curves appeared to give the best match to observed time drawdown data from the November/December 2007 pumping test. The aquifer may best be described as “semi-confined” as it is unconfined near the water table and becomes increasingly confined by clay and silt layers with increasing depth below the water table.

Aquifer specific yield (as opposed to storage coefficient) could not be estimated using graphical methods because the change in time-drawdown response characteristic of unconfined aquifer response (decrease in water level drawdown rate) was not fully developed during the 14 day pumping test.

C1-6 Discussion and Conclusions

COC conducted a 14 day constant rate pumping test between November 19 and December 3, 2007 using a pump installed in the Hay Ranch South well and monitoring groundwater levels in 11 wells located throughout Rose Valley. The greatest response to pumping was observed in the pumped well (107 ft of drawdown) and the Hay Ranch North well (6 ft of drawdown), approximately 2,750 ft north of the pumped well. Wells (Coso Ranch North and Coso Junction Store #1) in Coso Junction, 2 miles south of the pumped well, drew down as much as 0.4 ft during the test. Wells on Navy property 5 to 7 miles south of the pumped well did not appear to respond to pumping nor did a well located at the north end of the Little Lake Ranch property, 8 miles south of the pumped well. Changes were observed in the groundwater discharge rate from the Davis siphon well at Portuguese Bench that did not appear to be correlated with test pumping.

In general, aquifer response was consistent with that of a stratified, semi-confined aquifer. In this type of system, the aquifer would be expected to respond initially as if it were confined, and exhibit low storage coefficients, then as time goes on, vertical movement of groundwater from higher in the aquifer reaches the well screen causing a gradual reduction in the rate of groundwater level drawdown. If pumping continues for long periods of time at high rates, a second pronounced decrease in the rate of groundwater level decline is expected as soil near the groundwater table actually becomes dewatered. During the 2007 pumping test, the time-drawdown plots from the wells on the Hay Ranch property showed the initial rapid decline characteristic of low storage coefficients, then gradually drew down more slowly towards the end of the test indicating recharge from higher in the aquifer. However, specific yield could not be estimated based on data collected during the 2004 or 2007 pumping tests. As such, uncertainty in this parameter will have to be addressed using sensitivity analysis in the groundwater modeling analysis presented in Appendix C2.

The most significant finding of the 2007 pumping test was that the vertical hydraulic conductivity of the aquifer was estimated to be approximately three orders of magnitude lower than the horizontal hydraulic conductivity in the central part of Rose Valley. This is not unexpected because drillers' logs for wells drilled in the valley frequently report clay interbeds between sequences of sands and gravels; the presence of these clay layers impedes vertical groundwater flow. The effect of this natural vertical anisotropy is two-fold: it reduces the rate at which groundwater moves down from the water table, that is, it increases the time required before the onset of unconfined aquifer conditions, and, it increases the lateral distance at which pumping effects are propagated compared to a more uniform sand and gravel aquifer. Because the groundwater flow model developed for Rose Valley in 2006 used higher vertical hydraulic conductivity values, it may underestimate groundwater table drawdown developed at distance from the Hay Ranch pumping wells. Evaluation of the significance of this finding is presented in Appendix C2.

C1-7 References

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APPENDIX C2

NUMERICAL GROUNDWATER FLOW MODELING

ROSE VALLEY, INYO, COUNTY, CALIFORNIA

APPENDIX C2
NUMERICAL GROUNDWATER FLOW MODELING
ROSE VALLEY, INYO, COUNTY, CALIFORNIA

C2-1 Introduction

This appendix describes the numerical groundwater flow model developed for the Rose Valley, California, groundwater basin for the Environmental Impact Report (EIR) being prepared by MHA|RMT on behalf of Inyo County for the Coso Operating Company (COC) Water Extraction and Delivery System Project ("the Project"). For this project, GEOLOGICA, Inc. (GEOLOGICA) revised and recalibrated a numerical model previously developed by Brown and Caldwell (2006) for the Rose Valley groundwater basin. Groundwater flow evaluations were conducted using the U.S.G.S. MODFLOW computer code (McDonald and Harbaugh, 1988) implemented in the Groundwater Vistas graphical environment (Environmental Simulations, 2007).

C2-1.1 Purpose

The purposes of the evaluations and analysis described in this appendix were: to evaluate the groundwater conditions; analyze the potential impacts to groundwater resources in Rose Valley according to CEQA guidelines; and, to define mitigation measures to reduce potentially significant effects of the construction and operation of the proposed COC Hay Ranch project.

C2-1.2 Scope

The scope of this task included evaluating information regarding hydrogeologic conditions in Rose Valley, revising an existing numerical groundwater flow model of Rose Valley developed by Brown and Caldwell (2006) as needed to better represent those conditions, calibrating the model to new data from a pumping test conducted in November/December 2007, and developing scenarios to evaluate the proposed project, alternatives to the proposed project, and possible mitigation measures to reduce the impact of the proposed project. In addition, GEOLOGICA conducted sensitivity analyses to evaluate the impact of uncertainty in various input parameters and various withdrawal scenarios on model predictions.

C2-2 Environmental Setting

C2-2.1 Physiography

Rose Valley is a long, narrow valley located on the eastern flank of the Sierra Nevada Mountains in Inyo County, California. The alluvial portion of the groundwater basin is approximately 16 miles long from the southern end of the Haiwee Reservoir to just south of Little Lake, and has a maximum width of approximately 6 miles at its widest point. Rose Valley is topographically separated from the Owens Valley to the north by Dunmovin Hill, a topographic high that is composed of a massive landslide or series of debris flow deposits that originated from the Sierra Nevada range to the west (Bauer, 2002). Rose Valley is separated from the Indian Wells Valley to the south by a topographic high formed by a combination of granitic rocks and volcanic flows, and by the Little Lake Gap, which is an approximately 1,000 ft wide water-carved canyon within the volcanics (Bauer, 2002). **Figure C2-1** depicts physiographic features of the study area. The ground surface of the valley floor generally slopes gently to the south at a rate of 30 to 35 feet per mile.

C2-2.2 Geology

Rose Valley is a graben surrounded and underlain by igneous and metamorphic basement rocks of the Sierra Nevada and Coso Ranges. Alluvial sediments were encountered to depths as great as 3,489 feet in borings advanced in the north central portion of the basin (Schaer, 1981) and may extend to depths greater than 5,000 feet below ground surface (bgs) based on gravity surveys (GeoTrans, 2004). Younger (30 to 0.4 million years old) volcanic rocks of the Coso Range outcrop east of the central and northern Rose Valley and are predominately rhyolitic, dacitic, and andesitic in composition. The southern boundary of the Rose Valley groundwater basin is marked by outcrops of volcanic rocks related to eruptions within or flows from the Coso Range and volcanic cinder cones in the Red Hill area.

As summarized by Bauer (2002), the basin fill consists, in descending order, of recent alluvial fan deposits including debris flows from the bordering Sierra Nevada Mountains, volcanic deposits including basalt, ash, cinders, and tuff, lacustrine deposits of the Coso Formation, and older alluvial fan deposits from the Sierra Nevada and Coso Ranges. The recent alluvial deposits usually occur between ground surface and depths of up to 800 ft, and consist of a mixture of sands and gravels interbedded with clay. The maximum drilled thickness of these deposits occurs in the north central part of the valley near the Hay Ranch property. The Coso Formation uncomformably overlies basement rocks in the Coso Range and Rose Valley, and is comprised of a heterogeneous assemblage of primarily lacustrine deposits, with lesser amounts of volcanic tuff and alluvial fan deposits. Bauer (2002) described the Coso Formation as being comprised of four members in descending stratigraphic order: the Rhyolite Tuff Member, the Coso Lake Beds Member, the Coso Sand Member, and the Basal Fanglomerate Member.

- The Rhyolite Tuff Member occurs along the east side of the southern Haiwee Reservoir and extends south into the north end of the valley along the western slope of the Coso Range.
- The Coso Lake Beds Member reportedly is composed of alternating beds of fine-to-coarse-grained sand, arkosic, green clay with interspersed volcanic ash, and thin-bedded white rhyolitic tuffs containing pumice fragments. Deposits of the Coso Lake Beds Member reportedly extend north into the southern Owens Valley, where it is known as the Owens Lake Bed Member.
- The Coso Sand Member consists of poorly consolidated, fine-to-coarse grained alluvial gravels, sand, and red clay beds derived from the granitic basement rocks of the Coso Range and reworked Sierra Nevada alluvial fan materials. The Coso Sand Member occurs at depths from 1,500 ft to 3,000 ft bgs and the unit is thickest to the west, decreasing in thickness rapidly to the east.
- The Basal Fanglomerate Member was infrequently encountered in well borings drilled in the valley. It consists of reworked colluvial deposits localized by basement topography and structures.

C2-2.3 Hydrogeology

C2-2.3.1 Hydrostratigraphic Units

The principal hydrostratigraphic units that comprise the Rose Valley aquifer consist of recent alluvial deposits, and the Coso Lake Bed and Coso Sand Members of the Coso Formation. Older bedrock is largely impermeable or low permeability and typically impedes or excludes groundwater flow.

C2-2.3.2 Groundwater Occurrence and Flow

The groundwater table is typically first encountered during drilling within the upper portion of the recent alluvial deposits. Depth to groundwater ranges from 140 to 240 ft bgs in the north and central parts of Rose Valley to approximately 40 ft bgs at the northern end of the Little Lake Ranch near the south end of the valley. Depth to groundwater and calculated groundwater elevation used to develop the November 2007 groundwater elevation contour map are tabulated in **Table C2-1**. It should be noted that COC engaged triad / holmes associates in November 2007 to survey the location and reference point elevations of wells used for groundwater level measurements. These wells had not previously been surveyed. A groundwater elevation contour map of Rose Valley developed from depth to water measurements made on November 19, 2007 (**Figure C2-1)** indicates southeasterly groundwater flow along the axis of the northwest to southeast trending valley. With one exception, the November 2007 monitoring results were consistent with observations reported by Bauer (2002) for data collected in 1998. Water level measurements in Navy well 18-28, located in southeastern Rose Valley (**Figure C2-1**) indicated that the groundwater elevation in this area was approximately 10 ft higher than expected. This well was not available to previous investigations. The higher groundwater elevation is believed to be the result of impeded groundwater flow through the volcanic deposits south of the Red Hill cinder cone, towards Little Lake, and/or groundwater upwelling from the geothermal system underlying the Coso Range to the northeast.

Because the ground surface slopes more steeply to the south than the groundwater table, the groundwater table surfaces at and discharges from springs beneath Little Lake, sustaining the lake and the surface water discharge across the Little Lake Weir (see **Figure C2-2** for locations). Additional groundwater discharges from Coso Spring and the Little Lake Ranch siphon well as the ground surface elevation drops more steeply to the south of Little Lake.

Long term groundwater level monitoring conducted by COC indicates that groundwater levels have generally risen 1 to 2 feet throughout Rose Valley over the last 5 years (see **Figure C2-3**). This is most likely a response to increased precipitation recharge in the mountains during the last few years. There were no significant changes in groundwater extraction in Rose Valley nor identified groundwater recharge other than precipitation infiltration at higher elevations (discussed in Section C2-2.5). An approximately 1 ft rise was observed in the Cal-Pumice well north of the Hay Ranch property, 1.5 ft rises were observed in Lego and G-36 wells on Navy property seven miles southeast of Hay Ranch, and 2 ft rises were observed in the Hay Ranch wells. Groundwater levels in the LADWP wells (V816 and V817) fell from 2002 to mid-2005 then rose until the spring of 2007 when they began falling again.

The groundwater levels in the LADWP wells 2 miles south of the Haiwee Reservoir were approximately 170 ft higher than groundwater levels in the closest monitored well to the south, Cal-Pumice, throughout the long term monitoring period, suggesting a surface water flow component or input from a groundwater basin at a different groundwater elevation potential (i.e., Owens Valley). Groundwater levels in the LADWP wells were more variable than any other wells in the valley. The source of this variation is not well known. Water levels in Haiwee Reservoir and the flow rate in the LADWP aqueduct rose during the time water levels were monitored for the 2007 pumping test while groundwater levels in the LADWP wells fell; positive correlation between rising reservoir levels and groundwater elevation would be expected if seepage from the reservoir strongly influenced groundwater levels. The absence of correlation between reservoir levels and groundwater levels in the LADWP wells suggests varying rates of groundwater influx from Owens Valley may be the cause of groundwater level fluctuations at the north end of Rose Valley. Groundwater level monitoring data collected by COC beginning in September 2001 are tabulated in **Table C2-2**. Long term monitoring well locations are shown on **Figure C2-1**.

C2-2.3.3 Aquifer Properties

The transmissivity of the upper portion of the alluvial deposits was previously estimated to range from 9,000 to 69,800 gpd/ft (1,200 to 9,330 ft^2/day) based on data presented in the Rockwell Report (1980). Based on 24-hour pumping tests conducted in the Hay Ranch wells, GeoTrans (2003) concluded that the transmissivity of the Rose Valley aquifer near Hay Ranch was approximately 10,000 ft^2/day and estimated that the (horizontal) hydraulic conductivity was approximately 20 ft/day. GeoTrans concluded that they had insufficient data to estimate aquifer storage properties.

Based on a 14-day pumping test conducted in the Hay Ranch South well and monitored in wells throughout the valley, GEOLOGICA concluded that the best estimate of the transmissivity and horizontal hydraulic conductivity of the aquifer were approximately 14,750 ft^2/day and 24 ft/day, respectively (see Appendix C1). The vertical hydraulic conductivity of the alluvial aquifer in central Rose Valley was estimated to be 0.01 ft/day using a Neuman “Beta” coefficient of 0.01 from the aquifer testing type curve match and an aquifer thickness of 600 ft. The storage coefficient applicable to early time response and saturated soil below the water table was found to be 0.001.

C2-2.4 Surface Water

The average annual precipitation in Rose Valley ranges from 5 to 7 inches while the area’s annual evapotransporation rate is estimated to be 65 inches (CWRCB, 1993). Consequently, surface water bodies in the Rose Valley area consist of perennial springs sustained by groundwater flow, ephemeral streams and washes that mainly flow in the winter, and manmade lakes and reservoirs. Surface water features of interest are shown on **Figure C2-1** and discussed below.

C2-2.4.1 Haiwee Reservoir

The South Haiwee Reservoir is located at the north end of Rose Valley approximately 4 miles north of Hay Ranch. The crest of the south Haiwee Dam is located at approximately 3,766 ft MSL. Because of seismic stability concerns, the water level in the reservoir is currently limited to a maximum elevation 3,742 ft MSL. During construction of the dam, a trench was reportedly excavated to a depth of up to 120 ft below ground surface, until it tagged basalt bedrock, and backfilled with clay to seal the base of the dam (LADPS, 1916); however, the remainder of the reservoir is unlined. Weiss (1979) estimated that underflow from Haiwee Reservoir contributed approximately 600 acre-ft of water per year to the Rose Valley groundwater basin, indicating that the Reservoir is potentially an important source of recharge.

C2-2.4.2 Springs and Siphon Wells

Bauer (2002) identified several springs in Rose Valley including:

- Rose Spring located approximately 2 miles south of Haiwee Reservoir
- Tunawee Canyon Spring located approximately 3 miles southwest of the Hay Ranch
- Davis Siphon Well Spring located at Portuguese Bench
- Little Lake Fault Spring and Little Lake Canyon Spring located near the south end of Rose Valley, and
- Coso Spring located on the Little Lake Ranch property southeast of Little Lake.

Approximate spring locations are shown on **Figure C2-1**. As shown on Figure C2-1, only the Rose Spring is located within the numerical model grid area. No data were identified regarding the groundwater discharge rates from the Rose, Tunawee Canyon, Little Lake Fault, or Little Lake Canyon Springs. The groundwater discharge rate from the Davis Spring, referred to as the Davis Siphon Well in Appendix C1, was measured during the November/ December 2007 pumping test and ranged from 4.5 to 4.2 gallons per minute (gpm) or approximately 7 acre-ft/yr. The Davis Spring is located on the west central side of Rose Valley at Portuguese Bench at an elevation of approximately 3,870 ft MSL. Because the Davis Siphon well and spring discharge are located more than 600 ft higher than the groundwater table in the Rose Valley aquifer east of the Davis property at Coso Junction, they are not directly hydraulically connected to the alluvial aquifer. As discussed in Appendix C1, monitoring of the spring discharge rate during the 2007 pumping test did not provide any evidence of impact to the spring from pumping at Hay Ranch. Discharge from the spring that is not used on the Davis property infiltrates back into the ground after which it percolates downward to recharge the alluvial aquifer.

Based on their locations, elevations, and isotope chemistry (discussed in Section 3.2), the source of water for the Tunawee Canyon, Davis, and Little Lake Canyon springs is mainly derived from precipitation recharge in the Sierra Nevada mountains, while that for the Rose Spring appears to be a combination of Sierra Nevada precipitation recharge and seepage from Owens Valley and Haiwee Reservoir. Because the Tunawee Canyon, Davis, and Little Lake Canyon springs are located outside of the main body of the Rose Valley aquifer at elevations above the groundwater table in the Rose Valley aquifer and derive their water source wholly or mainly from Sierra Nevada precipitation recharge, they are unlikely to be impacted by the proposed project. The Rose spring, located near the north end of Rose Valley at an elevation (3,580 ft MSL) approximately 300 ft above the groundwater table in the aquifer, is also unlikely to be impacted by the proposed project. Based on its isotope chemistry, location, and elevation, Coso Spring, on the Little Lake Ranch property, is partially or wholly sourced by groundwater flowing from Rose Valley. Discharge from Coso Spring likely will be influenced by changes in groundwater conditions in Rose Valley; however, the spring is outside (south of) the model grid and is not directly represented in the model.

At the south end of Rose Valley, groundwater flow through the Little Lake Gap is constrained by bedrock on the west, an apparent subsurface bedrock rise below, and low or reduced permeability in the basalt lava flows to the east. The ground surface in the area slopes to the south, gently between the northern property line and Little Lake, then more steeply south of Little Lake. As a result of the combination of south-sloping ground surface and bedrock barriers to lateral or vertical groundwater flow, groundwater surfaces in this area to discharge via submerged springs into Little Lake and from the Coso Spring southeast of Little Lake (Figure C2-2). Groundwater discharging from the Coso Spring flows into the upper Little Lake pond (P-1). A siphon well located south of Little Lake (below the elevation of Little Lake and Coso Spring) brings additional groundwater to the surface where it is piped to the lower Little Lake pond (P-2). The intake for the siphon well is lower than the Little Lake Weir but higher than the Coso Spring. The siphon well is believed to be screened between elevations of approximately 3,120 and 3,130 ft MSL. Coso Spring is located at an approximate elevation of 3,120 ft MSL.

Little Lake Ranch staff can control the water level in the lake, allowing it to rise in the winter and fall in the summer by adjusting the height of a weir located at the south end of the lake. Overflow from the Little Lake weir is conveyed to the upper Little Lake pond (P-1) through an open channel. The discharge from both ponds flows through an open channel to the south where it is used to fill additional ponds when flow is adequate. As a result of evapotranspiration and infiltration, none of the surface water on the Little Lake Ranch property flows off the property (ULLR, 2000).

The only spring flow and groundwater discharge rate data for the Little Lake Ranch property were reported in Bauer (2002). Bauer (2002) measured the discharge rate from Little Lake, the flow rate from Coso Spring, and the stream flow rate in the North Culvert, south of pond P-2 and South Culvert, at the south end of the property, several times between 1996 and 1998. These data are summarized in **Table C2-3** and schematically illustrated on **Figure C2-4**. Bauer did not measure the flow rate from the siphon well. The North Culvert captures flow from the Little Lake Weir stream, Coso Spring, and the discharge from the upper and lower ponds. Bauer's measurements do not include evapotranspiration losses in the pond or conveyance system or identify possible measurement errors. As shown on **Figure C2-4**, the flow rate from Coso Spring ranged between 1,000 and 2,000 acre-ft/yr, averaging approximately 1,500 acre-ft/yr. The discharge rate from the Little Lake Weir ranged from zero in the summer of 1997 to 1,750 acre-ft/yr in the winter of 1998, averaging approximately 800 acre-ft/yr. In dryer years, e.g., 1997, Little Lake apparently does not discharge water across the weir in summer months.

C2-2.4.3 Lakes

One perennial lake, Little Lake (also described above), is located at the south end of Rose Valley approximately 9 miles south of the Hay Ranch property (**Figures C2-1** and **C2-2**). The U.S.G.S. Little Lake quad topographic map places the elevation of the lake at approximately 3,145 ft MSL. The lake is reportedly 3 to 5 ft deep and covers an area of approximately 75 to 90 acres at its maximum extent. The water level in the lake can be manipulated by raising or lowering boards in a discharge weir located at the south end of the lake but is also influenced by evaporation in the summer, as well as direct rainfall and storm water inflow from Little Lake Canyon wash to the west in the winter.

Bauer (2002) monitored the water level in the lake and the groundwater level in a monitoring well near the north end of the lake between January 6, 1997 and March 21, 1998. The variation in water level in Little Lake and groundwater elevation adjacent to the lake during that period is illustrated on **Figure C2-4**. The water level in the lake decreased nearly 1 foot between January and August and then rose nearly 1.2 foot in the following fall and winter. Any adjustments to the discharge weir in that time period were not noted by Bauer. Groundwater elevation measured in a well located approximately 500 feet from the north shore of Little Lake dropped nearly 0.8 ft between spring and summer 1997 and rose nearly 1 foot in the winter and following spring, but was always 3 foot or more higher than the lake level, indicating that the lake was always fed by groundwater. From this figure it appears that discharge of water from the Little Lake Weir stopped when the lake level dropped below approximately 3,142 ft but increased to an annualized rate of 1,750 acre-ft/yr when the lake water level rose to 3,143 ft MSL. Over this same period the discharge rate from Coso spring actually increased when the lake stopped discharging and decreased when the lake resumed discharging, indicating that the hydrologic system in this area is very complex. Based on these data, naturally occurring groundwater level fluctuations of 1 ft measured 500 ft north of Little Lake appears to correlate with significant changes in surface water flow rates on the Little Lake Ranch property.

C2-2.5 Groundwater Flow Components and Water Budget

The Rose Valley groundwater system is primarily recharged by mountain front recharge derived from precipitation and snowmelt that falls at higher elevation in the Sierra Nevada front range. As noted in Section C2-2.3.2, the south sloping groundwater table observed at the north end of Rose Valley indicates groundwater enters Rose Valley from Owens Valley to the north and/or from seepages losses from the south Haiwee Reservoir. This inflow is incorporated into the model.

As discussed in Section 3.2, some precipitation recharge likely occurs in the Coso Range on the east side of the valley but was conservatively neglected for the current modeling effort. Also, perhaps as much as 250 acre-ft/yr of groundwater may enter southeastern Rose Valley as upwelling from the Coso geothermal system based on proportions of chloride and stable isotopes in groundwater in southeastern Rose Valley, but was conservatively neglected in this analysis. Leakage from the LADPW aqueducts that traverse Rose Valley was assumed to be a negligible component of total groundwater inflow to the basin.

Currently, the principal groundwater outflow components consist of groundwater underflow and surface water discharges to the Indian Wells Valley to the south, and evapotranspiration from Little Lake and phreatophytic vegetation on the Little Lake Ranch property. Because of the dry climate, essentially all of the precipitation falling on Rose Valley is lost to evapotranspiration. However, because the groundwater table is located 40 or more feet below ground surface over all but the southern tip of the valley, evapotranspiration does not factor into the groundwater budget except on the Little Lake Ranch property. Inflow and outflow components of the groundwater budget for Rose Valley are discussed in more detail below.

C2-2.5.1 Groundwater Inflow Components

Principal inflow components consist of mountain front recharge, groundwater inflow from Owens Valley to the north and/or seepage from Haiwee Reservoir.

Mountain Front Recharge

Precipitation recharge in the Sierra Nevada range west of Rose Valley is the principal source of groundwater to the Rose Valley basin. Due to the rain shadow effect caused by the Sierra Nevada's, the precipitation rate in the Coso Range on the east side of Rose Valley is low. To be conservative, it was assumed that the evapotranspiration potential exceeded potential precipitation recharge throughout Rose Valley and the Coso Range. Methodologies to directly measure mountain front recharge are poorly defined; typically groundwater recharge from precipitation is estimated as a percentage of total recharge.

Brown and Caldwell (2006) concluded that precipitation rates in the Rose Valley area range from about 6 inches per year (in/yr) on the valley floor to up to 20 in/yr at the crest of the Sierra Nevada range and that only precipitation falling at elevations above 4,500 ft results in groundwater recharge. In the mountains, precipitation rate (including rainfall and snow melt) is strongly dependent on altitude. Danskin (1998) established an empirical relationship between precipitation rate and altitude based on precipitation and snow records collected routinely for more than 50 years in 20 survey stations along the western side of Owens Valley. Using the empirical relationship developed in the Danskin report, Brown and Caldwell estimated that the average precipitation rate for the elevation ranging from 4,500 ft to 6,500 ft was 10 in/yr, increasing to 15 in/yr for parts of the watershed above 6,500 ft. Using a geographic information system (GIS), to evaluate the contribution from areas of varying elevation in the Sierras west of Rose Valley, Brown and Caldwell estimated that the total precipitation volume that could potentially recharge the Rose Valley groundwater basin was approximately 42,000 acre-ft/yr.

For the purposes of the initial evaluation of potential impacts of groundwater development at Hay Ranch, they further assumed that only 10 % (4,200 acre-ft/yr) of the potential mountain front precipitation recharge actually reaches Rose Valley. Danskin (1998) used a value equivalent to 6% of Sierra Nevada range precipitation for the mountain front recharge component of the numerical groundwater flow model developed to evaluate groundwater development in Owens Valley. Williams (2004) estimated that mountain front precipitation recharge in Indian Wells Valley amounted to approximately 8% of precipitation in the Sierra Nevada range to the west. However, Williams noted that the Maxey-Eakin Method for estimating precipitation recharge in the Sierra Nevada range conservatively neglects areas receiving less than 8 in/yr of precipitation; consequently, higher recharge rates are possible. Because the mountain front precipitation recharge rate as assumed for the Brown and Caldwell groundwater flow model yielded reasonable calibration results in the steady state model, a recharge rate of 4,200 acre-ft/yr was also used in the revised numerical model developed for this EIR.

Groundwater Inflow/Seepage from the North

As noted previously, Weiss (1979) estimated seepage losses from the Haiwee Reservoir to be on the order of 600 acre-ft/yr. Previous investigators (Bauer, 2002; Brown and Caldwell, 2006) and GEOLOGICA's review of groundwater elevation contour patterns in the north end of Rose Valley indicate that groundwater inflow from southern Owens Valley and/or seepage losses from the south Haiwee Reservoir recharge the Rose Valley groundwater basin at the north end of the valley. Using a steady-state numerical groundwater flow model of the Rose Valley groundwater basin, Brown and Caldwell (2006) estimated the groundwater influx from the north to be approximately 788 acre-ft/yr, which is similar to the estimate of Weiss (1979). Recalibration of the numerical groundwater flow model for this study indicated a slightly higher groundwater inflow rate from the north (Owens Valley/Haiwee Reservoir) of 890 acre-ft/yr.

C2-2.5.2 Groundwater Outflow Components

Principal groundwater outflow components from Rose Valley consist of discharge to the Indian Wells Valley from the Little Lake area and an area in the southeast part of the valley, east of Red Hill, and evapotranspiration in the Little Lake area. Limited groundwater extraction was identified in Rose Valley.

Groundwater Discharge from Southeastern Rose Valley

Brown and Caldwell (2006) estimated that approximately 2,050 acre-ft/yr of groundwater discharges from Rose Valley in the southeast part of the valley (southeast of Navy well 18-28) as underflow to Indian Wells Valley. Williams (2004) concluded that existing estimates of recharge to the Indian Wells Valley significantly underestimated interbasin transfers and referenced an estimate of groundwater underflow from Rose Valley to Indian Wells Valley of 10,000 acre-ft/yr developed by Thompson (1929). Recalibration of the numerical groundwater flow model for Rose Valley indicated an underflow rate from Rose Valley to Indian Wells Valley in this area of 850 acre-ft/yr. This is less than half the value of 2,050 acre-ft/yr assigned to this term in the Brown and Caldwell (2006) numerical modeling analysis. This difference is discussed in the model calibration section.

Groundwater Discharge at Little Lake

Groundwater discharge by several processes in the Little Lake area is the dominant outflow component from Rose Valley. The processes operating at Little Lake include:

- Evaporation from the lake surface;
- Transpiration from phreatophyte plants on the property;
- Discharge from Coso Spring;
- Discharge from the Little Lake Weir; and
- Discharge from the Little Lake Siphon well.

Bauer (2002) estimated that evaporation from the Little Lake water surface consumes approximately 500 acre-ft/yr based on a lake surface area of 75-90 acres and evaporation rate of 80 in/yr. As discussed in Section 3.4, plant communities identified on the Little Lake Ranch property were described as akalai desert (saltbush scrub), palustrine (pond) and lacustrine (lake) wetlands, and riparian (creek) habitat. Beginning in 2000, Little Lake Ranch, Inc., conducted various projects intended to restore or enhance 90 acres of lacustrine wetlands, 10 acres of palustrine emergent wetlands, about 6 acres of palustrine/riparian habitat (1.6 mile long creek corridor), and an additional 220 acres of wetland and upland habitat, and 1 acre of wetland and associated upland habitat was acquired. As a result of shallow groundwater in this area, at least 300 acres of the 1,200 acre Little Lake Ranch property hosts various species of plants. Studies summarized in the U.S.G.S. Water-Supply Paper for Owens Valley (Danskin, 1998) concluded that wet land plant species in the desert climate prevalent in Owens (and Rose Valley) transpire between 20 and 36 in/yr. Using an average evapotranspiration value of 28 in/yr over the 300 acres yields an estimated 700 acre-ft/yr for transpiration processes (in addition to 500 acre-ft/yr assumed for surface water evaporation from Little Lake). Consistent with the 2006 numerical model, the model grid extends to the south end of Little Lake, as a result evaporation from ponds and the outfall stream and evapotranspiration from plants on the Little Lake Ranch property south of Little Lake are not explicitly represented in the model. Consequently, the evapotranspiration component of the 2007 numerical model includes 500 acre-ft/yr for evaporation from Little Lake and 200 acre-ft/yr for evapotranspiration from plants around the lake.

As discussed in Section C2-2.4.2, the flow rate measurements in the North Culvert, south of the lower pond (P-2) captures the discharge from the Little Lake Weir, Coso Spring, and Little Lake Siphon well. The discharge rate measured in the North Culvert ranged from 885 to 5,357 between January 6, 1997 and March 21, 1998 and averaged 3,000 acre-ft/yr. The domestic well by the ranch house, several irrigation wells, and the former Little Lake Hotel well are not believed to extract significant quantities of groundwater. The combined total of measured lake, spring, and groundwater discharges and estimated evapotranspiration losses in the Little Lake Ranch area is approximately 4,200 acre-ft/yr. All of the groundwater discharged in the Little Lake area that is not evaporated or transpired by plants (represented by flow observed at the North Culvert) infiltrates back into the ground on the property (approximately 3,000 acre-ft/yr) and continues as groundwater underflow to Indian Wells Valley (no surface water flow leaves the property). This is slightly lower than the value of 3,300 acre-ft/yr estimated by Williams (2004) for interbasin transfer from Rose Valley to Indian Wells Valley but does not include the groundwater underflow component from the southeastern Rose Valley discussed in the previous section.

Existing Extraction Wells

Currently, approximately 50 acre-ft/yr of groundwater production from wells occurs in Rose Valley. No significant agricultural irrigation has occurred in the valley since the Hay Ranch ceased alfalfa growing operations. As many as 30 domestic wells are believed to extract relatively small quantities of groundwater for domestic uses and small scale irrigation in the Dunmovin area. This pumpage is not represented in the groundwater flow model because it is believed to amount to less than 10 acre-ft/yr. The LADWP, Cal-Pumice, and Hay Ranch wells are not being pumped and are not known to have been used in the last five years. The Coso Ranch South well, southern Coso Junction Store well (Coso Junction #2), and the Cal Trans well at Coso Junction are regularly used for businesses in the area. The Coso Ranch North well and northern Coso Junction Store well (Coso Junction #1) are not being used at present. Cal-Pumice and the cinder mine near Red Hill reportedly takes 5 to 10 truckloads of water a day during the week from the Coso Ranch South well and Red Hill well, respectively, which was set in the model as a continuous withdrawal of 2005 cubic feet per day (cfd) or roughly 10 gpm. The Coso Junction Store well supplies the general store and COC offices in Coso Junction and was also represented as a continuous withdrawal of 2005 cfd. Extraction from the Cal Trans well was assumed to be negligible. Wells on the Navy property in Rose Valley including the Lego well, well G-36, and well 18-28 are not being pumped. Water wells on the Little Lake Ranch property were discussed in the previous section.

C2-2.5.3 Groundwater Budget

The groundwater elevation monitoring data suggest that groundwater inflows have equaled or slightly exceeded groundwater outflows from the Rose Valley groundwater basin in the past five years. Assuming that groundwater inflows equal outflows, that is, that steady state conditions prevail, the resulting conceptual Rose Valley groundwater budget is tabulated in the table below. Values from the 2006 numerical groundwater flow model are also listed for comparison purposes:

Table C2-4: Conceptual Groundwater Budget Components

Budget Components	2006 Model		2007 Model	
	Flow Rate, acre-ft/yr	Simulation Package used in Model	Flow Rate, acre-ft/yr	Simulation Package used in Model
Groundwater Inflow				
Mountain Front Recharge	4,191	Well	4,191	Well
Groundwater Underflow from the North	788	Constant Head	788	Constant Head
Total Inflow	4,979		4,979	
Groundwater Outflow				
Existing extraction wells	0	--	40	Well
Groundwater underflow to Indian Wells Valley exiting from southeastern Rose Valley	2,050	General Head	739	General Head
Evaporation from Little Lake and Evapotranspiration from adjacent Palustrine wetland plants	500	Evapo - transpiration	700	Evapo - transpiration
Plant transpiration on Little Lake Ranch property south of Little Lake (outside model grid)	0	--	500	--
Groundwater Discharge through Little Lake Gap to Indian Wells Valley	2,429	Drain	3,000	General Head
Total Outflow	4,979		4,979	

*Conceptual budget, simulated budget components were adjusted during model calibration process.

C2-3 Numerical Model Development

Brown and Caldwell (2006) developed a three-dimensional, numerical model of the Rose Valley groundwater basin which was then revised, and recalibrated, by GEOLOGICA for the EIR developed for the COC groundwater project at Hay Ranch. The revised model incorporates new groundwater elevation data collected by COC staff as well as time-drawdown data from a 14-day pumping test conducted at Hay Ranch in November/ December 2007. COC also engaged a surveyor in November 2007 to survey well locations and elevations which allowed a more accurate evaluation of groundwater elevation patterns in the valley than has been possible in the past.

The revised model is intended to represent the structure of the local aquifer system, as well as the inflow and outflow components discussed in previous sections. A steady-state version of the model was first (re)calibrated using groundwater elevation measurements made on November 19, 2007, prior to the start of the constant rate pumping test at Hay Ranch. The steady-state model incorporated available information regarding aquifer boundary conditions, discharge data measured at Little Lake, and pumping and recharge estimates discussed in Section C2-2. The steady-state model was then modified to a transient model by adding storage terms for saturated soil below the groundwater table (storage coefficient) and soil at the water table (specific yield) and calibrated to time-drawdown observations from the November/December 2007 pumping test. The transient version of the numerical model was then used to predict the response of the Rose Valley aquifer system proposed Hay Ranch project development alternatives as well as the added effect of pumping by the LADWP at it's wells at the north end of the valley. The model design and setup are discussed in detail in the following sections.

Groundwater flow evaluations were conducted using the U.S.G.S. MODFLOW computer code (McDonald and Harbaugh, 1988) implemented in the Groundwater Vistas graphical environment (Environmental Simulations, 2007).

C2-3.1 Model Domain and Finite Difference Grid

The model domain, which remains unchanged from the Brown and Caldwell (2006) modeling evaluation, covers 132 square miles, extending 8.25 miles in the east-west direction and 16 miles in the north-south direction. The model domain extends from the groundwater divide near the south Haiwee Reservoir on the north to the Little Lake Gap area to the south, and is bounded by impermeable boundaries representing the Sierra Nevada Mountains on the west and by Coso Range to the east. **Figures C2-1** and **C2-2** illustrate the location of the finite-difference grid relative to pertinent features of the Rose Valley basin. Consistent with the representation developed in the 2006 numerical model, the southern edge of the active portion of the model grid extends to the south edge of Little Lake; consequently, Coso spring, the Little Lake Ranch siphon well, and palustrine and riparian wetland areas south of Little Lake are not explicitly represented in the model.

The model domain was discretized into 64 rows and 33 columns. The cell size of the grid is 1/4 mile in both length and width, representing a 40-acre area. No flow (inactive) model cells were specified along the east and west margins of the model domain to represent the shape of the aquifer within basin fill deposits.

C2-3.2 Model Layer Configuration

Three model layers were originally used to represent the aquifer system in Rose Valley. As part of the recalibration process, GEOLOGICA subdivided the uppermost model layer into two layers to better represent the semi-confined behavior of the aquifer. The location of the contact between layer 1 and 2 was specified as being just below the bottom depth of shallower wells in the valley (including Cal-Pumice, Coso Store #1 and #2, and the Lego, G-36, and 18-28 wells) which is on the order of 400 ft bgs. The uppermost two layers (layers 1 and 2) were configured to represent: debris flows and debris avalanche in the Dunmovin Hill in the northern part of Rose Valley; the recent alluvial deposits in the center of Rose Valley, and interbedded volcanic deposits and alluvium in the south and southeast part of Rose Valley. Layer 1 was specified as unconfined with transmissivity determined by MODFLOW as the product of horizontal hydraulic conductivity and current saturated thickness and storage represented using specific yield. Layers 2, 3, and 4 were configured as confined units in MODFLOW with transmissivity calculated as the product of horizontal hydraulic conductivity and the layer thickness at that location and storage represented using a confined aquifer storage coefficient. Layer 3 was configured to represent the Coso Lake Beds Member and modeled as confined as described above. Layer 4 was configured to represent the Coso Sand Member and modeled as confined as described above.

Model layers 1 and 2, together, 3, and 4, were constructed to have variable thickness and spatial extent. The basis for specifying layer thickness and the bottom elevation of each of layers 2, 3, and 4 is described in Brown and Caldwell (2006). Contour maps of the bottom elevations of layers 1, 2, and 3 are depicted in the Brown and Caldwell report (Figures 8, 9 and 10) corresponding to the bottom elevations of layers 2, 3, and 4 in the current model. Total model thickness from land surface ranged from 150 ft within Little Lake Gap to 3,500 ft near Hay Ranch.

C2-3.3 Model Boundary Conditions

The active portion of the model domain is bounded on the west and east by igneous and metamorphic rocks of the Sierra Nevada and Coso Range which are presumed to be impermeable. Groundwater discharge to Indian Wells Valley in the southeast part of Rose Valley (east of Red Hill) through fractured basalt flows and/or basalt flows overlying alluvial deposits was represented using a head dependent boundary condition. Model cells that represent bedrock areas form the inactive portion of the model domain and also serve as no-flow boundaries. Boundary conditions specified in Layers 1 and 2, 3, and 4, are depicted in **Figures C2-5**, **C2-6**, and **C2-7**, respectively.

No Flow Boundaries/Inactive Cells

The location of no flow boundaries, and thereby, inactive cells in the model domain were essentially the same as those specified in the Brown and Caldwell (2006) model.

Specified Flux Boundaries

Along the western boundary of the active mode domain, Brown and Caldwell (2006) used specified flux boundaries to represent mountain front recharge derived from precipitation and snowmelt that falls on the Sierra Nevada (**Figures C2-5**, **C2-6**, and **C2-7)**. Due to the steep topography present on the east side of the Sierra Nevada Mountains, and the absence of well developed drainages on the Rose Valley basin floor, it was assumed that the mountain front recharge could infiltrate to all model layers, and the total mountain front recharge of 4,200 acre-ft/yr was distributed from top to bottom at a ratio of 2:1:2 based on hydraulic conductivity and layer thickness with less recharge assumed to infiltrate the low permeability Coso Lake Beds Member (layer 3). This resulted in specified fluxes of 1,680 acre-ft/yr in layers 1 and 2, 840 acre-ft/yr in layer 3 and 1,680 acre-ft/yr in layer 4.

Constant Head Boundary

On the northern edge of the model domain, a constant head (CH) boundary was used to represent the groundwater divide near the south Haiwee Reservoir (**Figure C2-5**). The groundwater elevation at this boundary was fixed in these cells at a value of 3,750 ft MSL based on groundwater level measurements made by Bauer in 1998 (Bauer, 2002).

Groundwater elevations at the south end of Owens Valley near the Haiwee Reservoirs most likely vary with time as a result of changes in pumping rates in Owens Valley and changes in water levels in the reservoirs. No time-series groundwater level measurement data were identified therefore this elevation is fixed in the model. The magnitude of the groundwater inflow rate across this boundary from Owens Valley and/or seepage from Haiwee Reservoir was controlled by modifying the hydraulic conductivity of the alluvium represented by layers 1 and 2 in the model during the model calibration process.

Evapotranspiration

Surface water evaporation from Little Lake and evapotranspiration from phreatophyte plants around the lake was represented using the MODFLOW Evapotranspiration (ET) package with ET cells specified in Layer 1 (**Figure C2-5**). The extinction depth for the ET cells was set to 15 ft below ground surface, the same value as was used in the 2006 model, and consistent with the value used in the USGS model of Owens Valley (Danskin, 1998). Bauer (2002) estimated the surface water evaporation rate from Little Lake to be approximately 500 acre-ft per year, presumeably when the lake is at its maximum depth. The relationship between lake level and surface area is unknown, presumably, at lower water levels the lake covers less area and may lose less water to evaporation. MODFLOW reduces the calculated evapotranspiration loss in proportion to the groundwater table depth below ground surface; no evapotranspiration occurs when the groundwater table is at or below the extinction depth (15 ft), half as much evapotranspiration is calculated when the groundwater table is located at half the extinction depth (7.5 ft) below ground surface. The evapotranspiration rate was adjusted during model calibration to yield a total evapotranspiration loss of approximately 500 acre-ft per year in the steady state model, consistent with the 2006 model.

General Head Boundaries

The groundwater outflow to Indian Wells Valley from the southeast part of Rose Valley near well 18-28 was simulated using general head boundary (GHB) cells specified in layers 3 and 4 (**Figures C2-6** and **C2-7**). GHB cells in MODFLOW allow groundwater inflow or outflow from the model at a rate dependent on the difference between groundwater elevation in the model and a specified elevation and a conductance assigned to the general head boundary cell; however, the groundwater elevation in the GHB cell is calculated by MODFLOW during a simulation, not fixed like a CH boundary cell. Brown and Caldwell used groundwater elevations measured in the Lego Well in Rose Valley and historical water level elevations measured in the Indian Wells Valley (presented in Bloyd and Robson, 1971) to estimate the flow across this boundary. The conductance and groundwater elevation in the GHB cells were adjusted during the model calibration process to better simulate groundwater elevations observed in the southeast part of Rose Valley.

The groundwater outflow to Indian Wells Valley in the Little Lake area was represented using GHB cells specified at the south end of the model grid near Little Lake (**Figure C2-5**). This is a departure from the treatment of these groundwater outflow terms in the Brown and Caldwell model in which MODFLOW drain cells were used to represent groundwater discharge and the evaporation package was used to represent evaporation from Little Lake. The principal items of interest in the Little Lake area are groundwater elevation near the lake, which impacts lake level and discharge, and the amount of groundwater flow available for discharge to springs and transpiration by wet land plants. The MODFLOW evaporation package varies the estimated evaporation rate depending on the calculated depth to groundwater, which is not currently an issue in this area. The MODFLOW drain package stops calculating flow to the drain when the local groundwater elevation drops below the base of the drain. It is anticipated that groundwater will continue to discharge to Indian Wells Valley at a reduced rate, even if pumping draws groundwater levels down below the level of Little Lake at some point in the future; thus the MODFLOW drain package does not adequately represent possible worst case conditions in the area. Use of MODFLOW GHB cells in this area better represents hydrogeologic conditions and allows both groundwater elevation and discharge rate to be easily monitored during simulations.

C2-3.4 Initial Aquifer Parameters

Aquifer horizontal hydraulic conductivity for the revised model was initially specified with the distribution developed by Brown and Caldwell which ranged from values of 0.28 to 100 ft/day in layers 1 and 2, 0.03 to 2.8 ft/day in layer 3, and 0.28 ft/day in layer 4. Confined aquifer storativity was initially specified as 2×10^{-6}/ft based on the storage coefficient of 0.001 estimated from the 2003 pumping test (GeoTrans, 2003) and an average effective aquifer thickness of 600 ft. Layer 1 specific yield was initially specified as 10 % as specified in the original model. Aquifer vertical hydraulic conductivities were initially specified as the same value as horizontal hydraulic conductivity except near the Hay Ranch where the vertical hydraulic conductivity was reduced to 1 ft/day to be more consistent with the lower vertical hydraulic conductivity indicated by the November/December 2007 pumping test results.

C2-3.5 Model Recalibration

Calibration of the numerical model of groundwater flow conditions in Rose Valley, was conducted in an iterative process which consisted of attempting to match groundwater level drawdown observed during the 2007 pumping test, which was mainly parameters local to the Hay Ranch, then matching model parameters were adjusted across the entire model domain to better fit groundwater inflow/outflow calculations and groundwater elevations measured prior to the pumping test. This process was repeated until both the steady-state model fit the November 2007 groundwater elevation data and the transient version of the model fit the pumping test data.

C2-3.5.1 Calibration to 2007 Pumping Test Data

Time-water level measurements from the Hay Ranch North and the Coso Ranch North wells were used to calibrate the revised numerical model. Boundary groundwater discharge inflow and outflow rates were fixed for this evaluation. A model simulation of the Hay Ranch South well pumping at a rate of 1,925 gpm for 14 days was developed with monitoring points at the Hay Ranch North and Coso Ranch North well locations and other locations in Rose Valley. Then horizontal and vertical hydraulic conductivity, confined aquifer storativity, and unconfined aquifer specific yield were adjusted until a best fit was obtained between observed and model predicted groundwater level drawdown. Plots of predicted versus observed groundwater level drawdown versus time for the Hay Ranch North and Coso Ranch North wells are shown on **Figure C2-14**. A good fit was obtained to the Hay Ranch North well data; the observed water level response of the Coso Ranch North well was complicated by unmetered wells pumping in the area and barometric pressure induced water fluctuations, neither of which are readily reproduced in the numerical model so the model fit to these data was more difficult to assess.

C2-3.5.2 Steady-State Model Recalibration

After developing preliminary, revised estimates of aquifer hydraulic parameters by calibrating to pumping test data, groundwater elevations were simulated and compared to observed elevations. Then the steady-state model was further recalibrated to improve the match between the observed groundwater elevation distribution throughout Rose Valley and estimated groundwater inflow/outflow components. During the model calibration process, mountain front recharge rates and constant head boundary elevations remained unchanged. Hydraulic conductivity and general head boundary cell conductance were adjusted until a reasonable match was obtained between observed and predicted groundwater elevations and groundwater flow component targets. Groundwater flow rate targets consisted of: a total groundwater budget (inflow and outflow) of approximately 5,000 acre-ft/yr; with approximately 800 acre-ft/yr for inflow from Owens Valley, and no more than 4,200 acre-ft/yr discharged to the Little Lake Gap. Groundwater elevation targets were developed from data presented in **Table C2-1**.

C2-3.5.3 Calibrated Model Parameters

Aquifer storage terms were estimated from the pumping test calibration. Final values of 7×10^{-7}/ft were identified for confined aquifer storativity (applicable to layers 2, 3, and 4) and 3 % for specific yield (applicable to layer 1 only) based on calibration to the pumping test data.

The distribution of calibrated model hydraulic conductivity values are illustrated on **Figures C2-8** through **C2-11** for layers 1 through 4, respectively. Horizontal hydraulic conductivity ranged from values of 0.08 to 200 ft/day in layers 1 and 2, 0.03 to 2.8 ft/day in layer 3, and a constant value of 0.28 ft/day in layer 4. The main changes in the hydraulic conductivity distribution developed for the recalibrated model were: 1) lower vertical hydraulic conductivity in the alluvial deposits near the central part of Rose Valley; 2) lower horizontal hydraulic conductivity in the area south of the Red Hill cinder cone where volcanic deposits interfinger with alluvial sands; and, 3) slightly higher horizontal hydraulic conductivities in the alluvial deposits near Little Lake and to the north. The horizontal hydraulic conductivity of alluvial deposits near the Hay Ranch, represented by layers 1 and 2, was unchanged from the 2006 model. A lower vertical hydraulic conductivity value of 0.019 ft/day (compared to 2.4 ft/day previously) was used in this area based on the results of the 2007 pumping test.

C2-3.5.4 Calibrated Model Accuracy

The accuracy of the model calibration efforts was evaluated by comparison of observed and simulated groundwater elevations; and by comparison of conceptual and simulated groundwater budgets. **Figure C2-12** shows a comparison of predicted groundwater elevation contours versus groundwater elevations observed in November 2007. **Figure C2-13** shows a plot of predicted versus observed groundwater elevation at the eleven target locations for the steady state model. A perfect match is indicated by the dashed line on **Figure C2-13**.

The model simulated groundwater elevations scatter closely around the ideal calibration line throughout the central and southern portions of Rose Valley but are lower than the observed values in the Cal-Pumice and LADWP wells at the north end of the valley. Excluding the values for the Cal-Pumice and LADWP wells, the residual and absolute mean errors were –1 and +2.2 ft which are less than 1 % of the observed range in groundwater elevations along the length of Rose Valley. Including the Cal-Pumice and

LADWP wells, the residual and absolute mean errors are still less than 5% of the observed range in groundwater elevations. The discrepancy between predicted and observed groundwater elevations at the north end of the valley points to a shortcoming in the data available for developing the model, and, consequently, a shortcoming in the model. As noted previously, groundwater elevations are expected to vary seasonally near Haiwee Reservoir but have not been measured since Bauer's work in 1998. Data from 1998 monitoring were used to develop the boundary conditions for the north end of the model.

Figure C2-14 presents a comparison of the simulated versus observed groundwater level drawdown in the Hay Ranch North and Coso Ranch North wells during the November/December 2007 pumping test. The model simulates the drawdown observed in the Hay Ranch North well reasonably well with an average error of 0.2 ft but does less well with the Coso Ranch North well. The model predicted no more than 0.1 ft of drawdown in the Coso Ranch North well while the groundwater level may have drawn down as much as 0.25 ft during the pumping test. The model predicts nearly 0.3 ft of drawdown in the Cal-Pumice well which cannot be confirmed because of a pre-existing falling water level trend in that well. The model predicts that less than 0.01 ft of drawdown develops in the Lego, 18-36, or Little Lake Ranch North wells, consistent with field observations.

The accuracy of the calibration was also evaluated by comparing the conceptual and simulated water budgets. Previous estimates of the groundwater underflow into Rose Valley from Owens Valley/Haiwee Reservoir ranged from 600 to 788 acre-ft/yr. The recalibrated model estimated the groundwater inflow from the north to be 890 acre-ft/yr. Brown and Caldwell estimated the groundwater underflow to Indian Wells Valley from southeastern Rose Valley to be as much as 2,050 acre-ft/yr. The recalibrated model estimated the groundwater underflow by this pathway as 850 acre-ft/yr. The groundwater outflow from the Little Lake area including evaporation losses has been estimated to be between 2,900 and 3,800 acre-ft/yr. The recalibrated model estimated the groundwater outflow from the Little Lake area to be 4,200 acre-ft/yr but that total included transpiration losses from wetland plants that were not considered in previous estimates.

C2-3.5.5 Model Limitations/Data Gaps

The process of reviewing hydrogeologic data for the site and recalibrating the model identified several data gaps and resulting limitations of the numerical groundwater flow model developed for Rose Valley. These include:

- Lack of recent seasonal groundwater elevation data north of Rose Valley adjacent to the southern Haiwee Reservoir. As discussed in Section C2-3.5.4, the model underpredicted steady state groundwater elevations in the Cal-Pumice and LADWP wells by 16 and 105 ft, respectively while matching groundwater elevations in wells in the remainder of the valley to within 1 to 5 ft. The model also represents groundwater elevation as fixed at the north end of the model grid which is inconsistent with monitoring data for the LADWP wells which indicated groundwater level fluctuations of up to 7 ft seasonally. The cause of these fluctuations and the discrepancy between predicted and observed groundwater elevations in this area are not well understood and need further investigation. However, because the model matches groundwater elevation observations in central and south Rose Valley reasonably well, it is useful for prediction of pumping impacts at the south end of the valley.

- Lack of transmissivity or storativity data outside the Hay Ranch area. It should be noted that estimated aquifer hydraulic parameters were evaluated by conducting a pumping test at the Hay Ranch. As noted previously, drawdown was only observed near the Hay Ranch, so estimates of aquifer parameters elsewhere in Rose Valley are heavily dependent on assumptions and parameters built into the numerical model.
- Lack of recent seasonal flow measurements or water level measurements on the Little Lake Ranch property. The most recent data for Little Lake water level and groundwater and spring discharges at the Little Lake Ranch date to 1998. While groundwater elevations in Rose Valley appear to be similar or higher than Bauer observed in 1998, suggesting the flow measurements are still applicable, future monitoring programs should include the hydrogeologic features at Little Lake.

C2-4 Analysis of Groundwater Development Scenarios

This section discusses the evaluation of several groundwater development scenarios. For these scenarios, the numerical groundwater flow model developed for Rose Valley was run in transient mode, using the calibrated aquifer hydraulic conductivity and boundary cell elevation, conductance, and flow values identified in Section C2-3.5.3. An aquifer storage coefficient value of 7×10^{-7}/ft was used for model layers 2, 3, and 4.

The model calibration to the 2007 pumping test data yielded an estimated specific yield for the alluvial aquifer of 3 %. This value is quite low for typical sand and gravel aquifers such as occur in Rose Valley and is believed to underestimate the specific yield value applicable to multi-year pumping. Specific yield values estimated from pumping tests frequently underestimate the actual drainable porosity of the aquifer (see Neuman, 1975; Zhan and Zlotnik, 2002). Published values of specific yield (Johnson, 1967; Morris and Johnson, 1967) range from 2 % for clay to 35 % for well-graded gravels as tabulated in Table C2-5. Groundwater-yielding sediments encountered in Rose Valley consist primarily of sand and gravel interbedded with clays; most of the groundwater will come from the more readily drainable sand and gravel horizons. Because specific yield could not be determined from the pumping test data, a range of values corresponding to high, medium, and low values of 30, 20 and 10 % were used in the project development impact analyses discussed below.

C2-4.1 Full Project Development

Full project development consists of pumping the two Hay Ranch wells at a combined total extraction rate of 4,839 acre-ft/yr with pumping evenly divided between the two wells. For this evaluation, 180 year transient simulations were performed with groundwater table drawdown and groundwater discharge rates reported at regular intervals to evaluate aquifer conditions after the specified 30 years of continuous pumping. All aquifer parameters were maintained as described for the calibrated model with the exception that specific yield in the uppermost model layer was set to values of 10%, 20% or 30% for individual model runs to assess sensitivity to this parameter.

Table C2-5: Values of Specific Yield from Johnson, 1967

Soil Type	Minimum	Average	Maximum
Clay	--	2	5
Sandy clay (mud)	3	7	12
Silt	3	18	19
Fine sand	10	21	28
Medium sand	15	26	32
Coarse sand	20	27	35
Gravelly sand	20	25	35
Fine gravel	21	25	35
Medium gravel	13	23	26
Coarse gravel	12	22	26
Volcanic Tuff	--	21	--
Till, predominantly sand	--	16	--
Till, predominantly gravel	--	16	--

C2-4.1.1 Evaluation of Potential Drawdown Impacts

Numerical values for initial groundwater elevation throughout the active portion of the model domain were established by running a steady state simulation with aquifer parameters and boundary conditions set as described in preceding sections with no pumping whatsoever at Hay Ranch. A transient version of the calibrated numerical model, with the same aquifer parameters and boundary conditions as the steady state model, was used to predict aquifer response to various rates and durations of pumping at Hay Ranch. Drawdown at selected observation points was calculated by having MODFLOW import the final groundwater elevations from the steady state model and subtract predicted groundwater elevations at these observations points from the output of the transient model simulation run. These values were then saved as a series of time-drawdown predictions at selected monitoring points.

C2-4.1.2 Evaluation of Potential Groundwater Flow Impacts

Numerical values for initial groundwater flow rates in various portions of the model domain were established by running a steady state simulation with aquifer parameters and boundary conditions set as described in preceding sections with no pumping whatsoever at Hay Ranch. A transient version of the calibrated numerical model, with the same aquifer parameters and boundary conditions as the steady state model, was used to predict aquifer response to various rates and durations of pumping at Hay Ranch. Changes in groundwater flow rates in various portions of the model were then evaluated by comparing the groundwater flow rates predicted in the steady state model with no Hay Ranch pumping to the groundwater flow rates predicted in the transient model with specified rates and duration of pumping at the Hay Ranch wells. The Groundwater Vistas groundwater Mass Balance Export function to extract groundwater flow rates from selected portions of the model domain in the steady state and transient model simulations, respectively.

C2-4.2 Cumulative Effects Analysis

The Cumulative Effects Analysis consisted of developing and running a transient model simulation scenario in which the Hay Ranch wells were pumped at the full project development rate of 4,839 acre-ft/yr plus pumping was simulated at the LADWP wells at a rate totaling 900 acre-ft/yr using the MODFLOW well package. Initial attempts at performing this analysis failed because the model cell in which LADWP well V816 is located went dry before the end of the simulation, terminating groundwater extraction at that location.

The extraction rate from the LADWP property was then dispersed between several well nodes and eventually reduced until a stable simulation run could be conducted. That occurred when extraction of approximately 770 acre-ft/yr was distributed between three pumping nodes. Potential impacts to groundwater elevation and flow rates were then performed as described in Sections C2-4.1.1 and C2-4.1.2, respectively.

C2-5 Analysis of Mitigation Measures

Potential measures to mitigate possible impacts to groundwater resources of Rose Valley caused by implementation of the full development project rate of 4,839 acre-ft/yr extraction from the Hay Ranch wells were evaluated using the numerical groundwater flow model. The mitigation measures evaluated consisted of:

- Reducing Hay Ranch pumping rates below the full project development rate of 4,839 acre-feet per year;
- Reducing Hay Ranch pumping duration from the full project duration of 30 years; and,
- Augmenting the water supply to Little Lake by extracting groundwater on the Little Lake Ranch property and pumping that water into the lake.

Techniques for evaluating potential groundwater table drawdown and changes to groundwater flow rates used in the evaluation of potential mitigation measures are the same as those described in Section C2-4 and are not discussed further here.

C2-5.1 Little Lake Water Supply Augmentation

The calibrated numerical groundwater flow model was used to evaluate the potential for augmenting the water supply available to maintain the water level in Little Lake. Prolonged pumping of the Hay Ranch wells could result in groundwater table drawdown near Little Lake that could reduce groundwater inflow to the lake and consequently reduce lake levels. A potential mitigation measure to restore or maintain lake levels would involve pumping groundwater from an existing or new well on the Little Lake Ranch property and pumping the water into Little Lake. Augmentation by pumping groundwater from one of the Little Lake Ranch wells into the lake reportedly has been conducted in the past; however, details of previous augmentation efforts were not available for review. Adding water to the lake would provide water closer to the ground surface for irrigation needs and maintenance of phreatophyte plant communities.

Augmentation might only be needed during the summer months when phreatophyte plants actively grow and transpire soil moisture.

Augmentation was evaluated by specifying groundwater extraction from a well node located on the Little Lake Ranch property and injection of an equal amount of water via a well node located within the footprint of Little Lake. The amount of groundwater needed to augment lake levels is difficult to estimate at this time because there are not much data on the hydrologic features at the lake. A simulation in which groundwater was extracted from the Little Lake Ranch House well at an annualized rate of 740 acre-ft/yr (450 gpm) and reinjected into Little Lake was conducted. The augmentation simulation assumed that 1) production at the Hay Ranch would be reduced to 2,424 acre-ft/yr (1,500 gpm) beginning in the 20th year after project startup, and, 2) that extraction from the Little Lake Ranch House well coupled with injection into Little Lake would start at the same time. Results of the augmentation simulation indicated that water could be added to Little Lake to maintain surface water flows. However, groundwater drawdown on the property could be increased over and above the amount induced by pumping the wells at Hay Ranch as a result of the groundwater extraction. Because most of the groundwater diverted into the lake ultimately infiltrates back into the ground on the property, the increased drawdown is expected to be small. For this augmentation scenario, the model predicted an increase in drawdown of approximately 0.1 ft below Little Lake as a result of the pumping on the property and increased approximately 1 to 2 ft around the Little Lake Ranch House well.

Analysis of the capacity of one or more of the wells on the Little Lake Ranch property would need to be completed early in the project, preferably during the baseline monitoring period, to establish the viability of this mitigation option. An analysis of the interaction between groundwater and lake levels and discharge rates would also need to be completed during the baseline monitoring period to evaluate the potential amount of water needed, should an augmentation scheme be employed later in the life of the project.

C2-6 References

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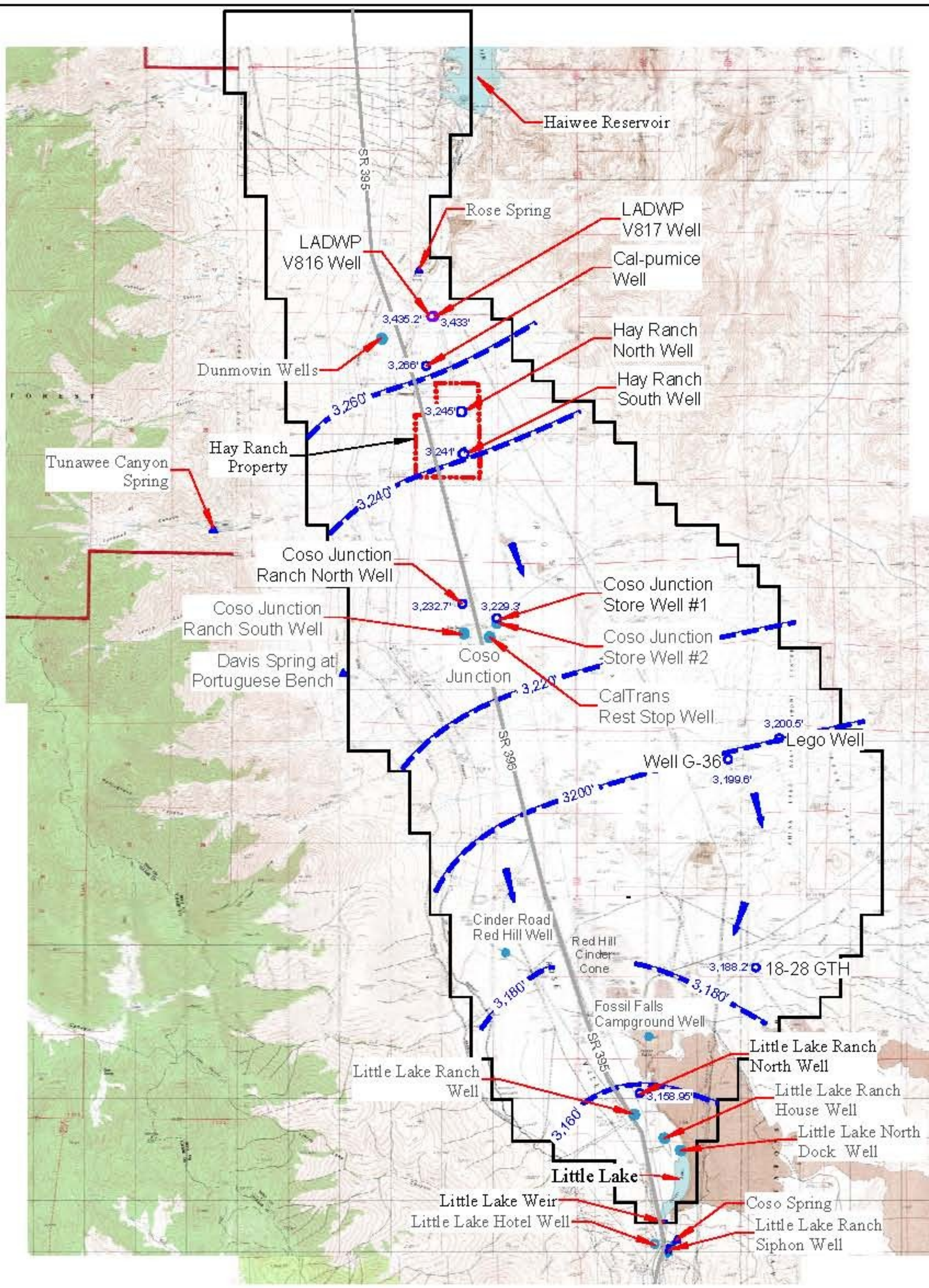


Key

- Well Monitored during Pumping Test
- 3158.95' Groundwater Elevation, ft AMSL
- 3,160' Groundwater Elevation Contour, ft
- Groundwater Flow Direction
- Boundary of Numerical Model
- Spring or Siphon Well

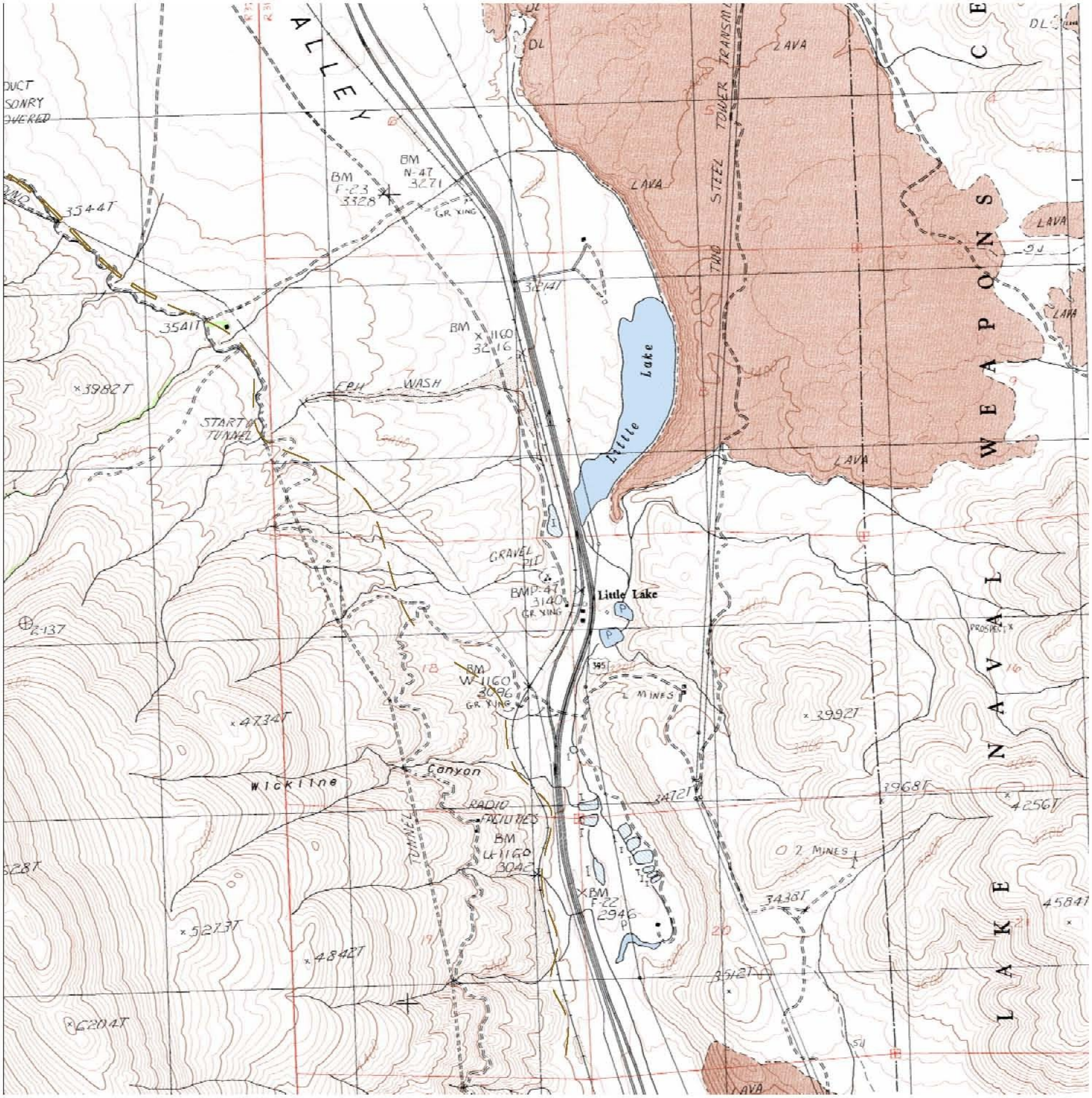
Approximate Scale in miles

0 1 2

N

Study Area Map and Groundwater Elevation Contour Map - November 2007

Figure C2-1



Key

Approximate Scale in miles

0 0.5

N

▲ Spring or Siphon Well

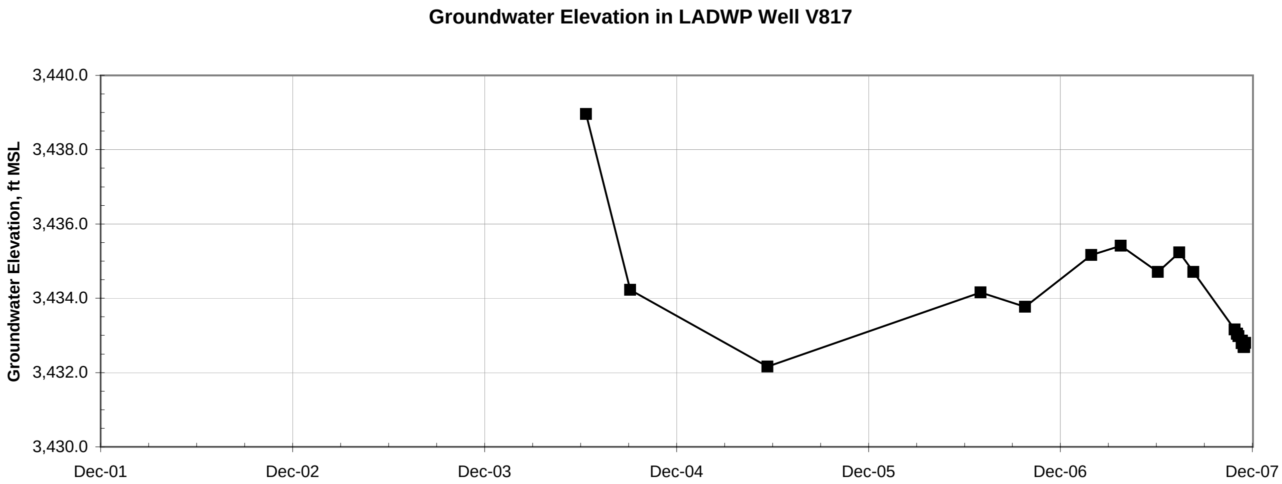
● Pumping Well

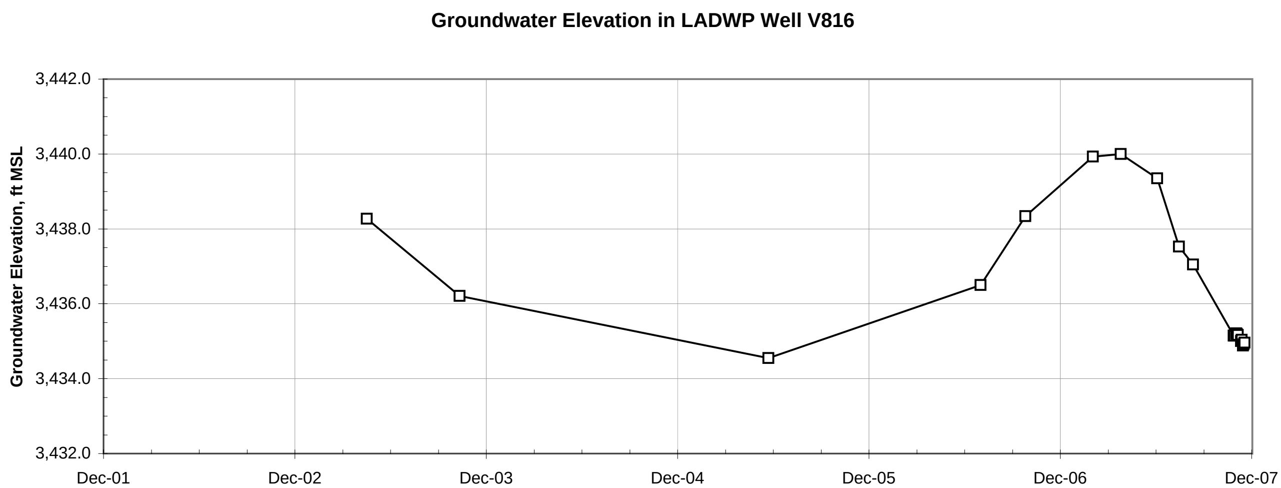
○ Out-of-Use Well

Hydrologic Features of Little Lake Ranch

Figure C2-2

Figure C2-3
Rose Valley Groundwater Level Hydrographs





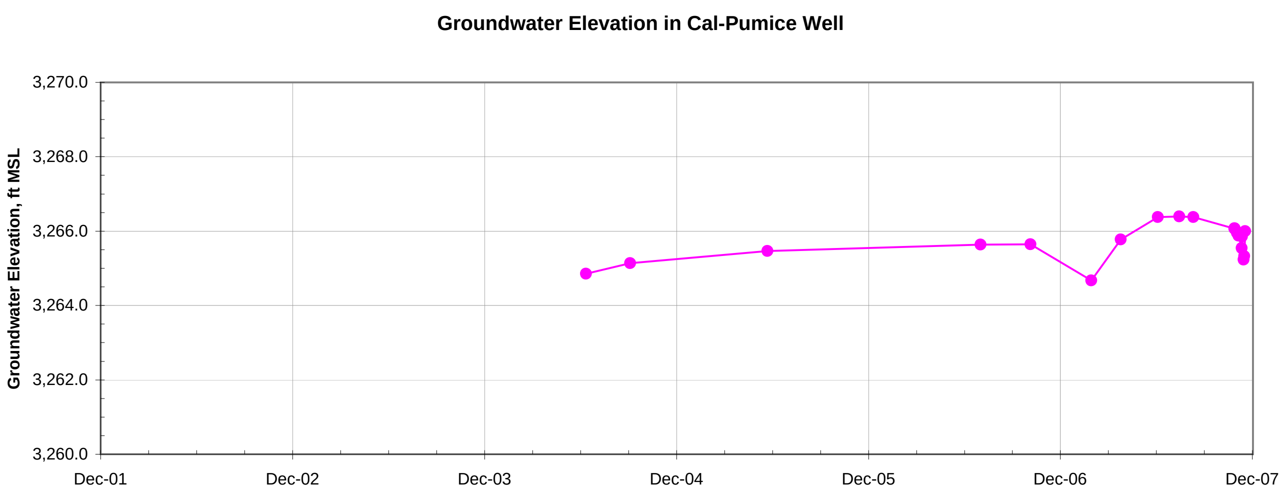
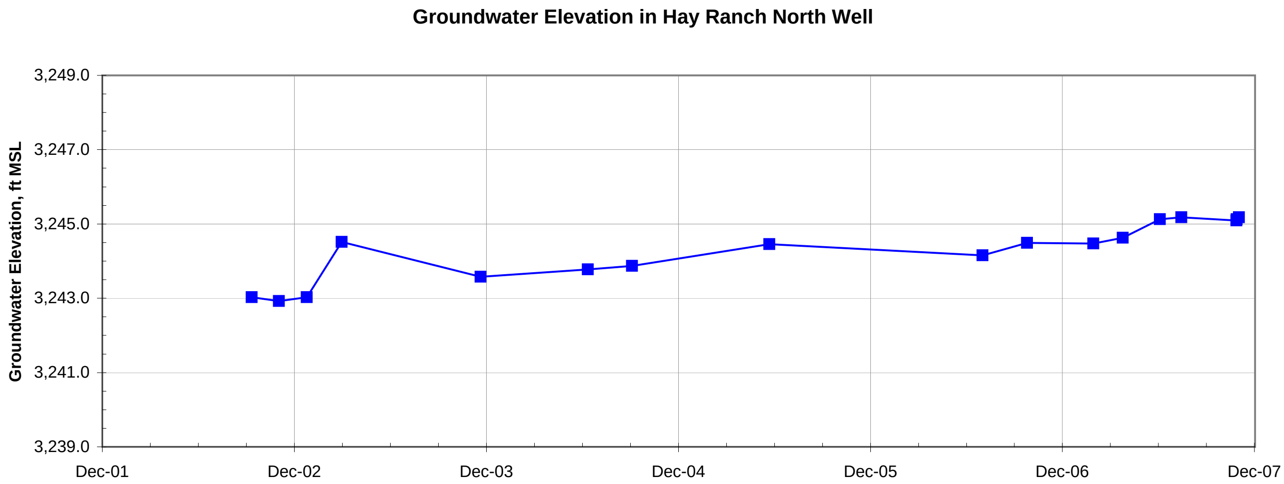
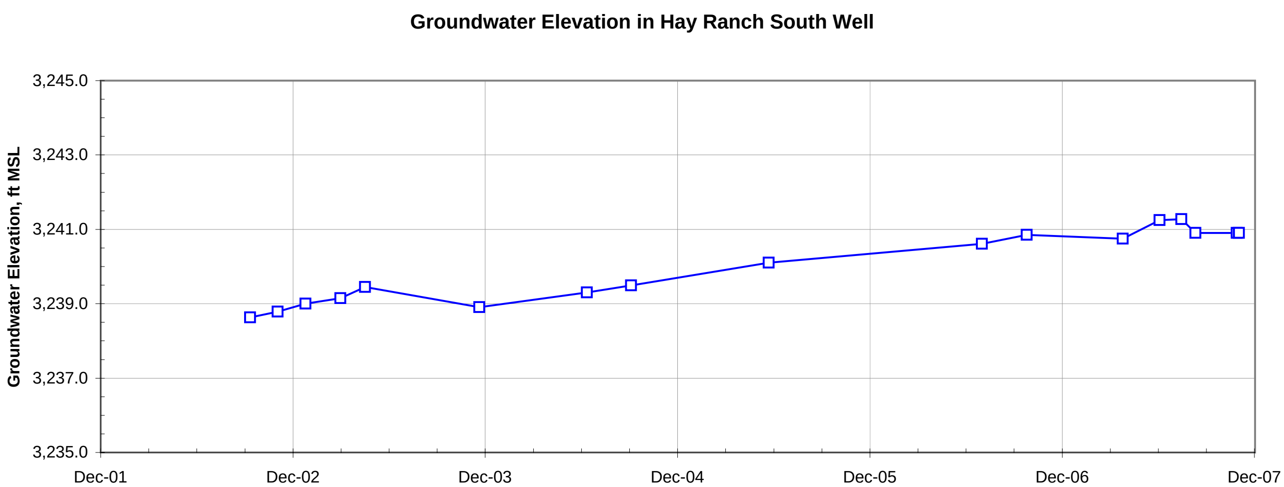


Figure C2-3
Rose Valley Groundwater Level Hydrographs





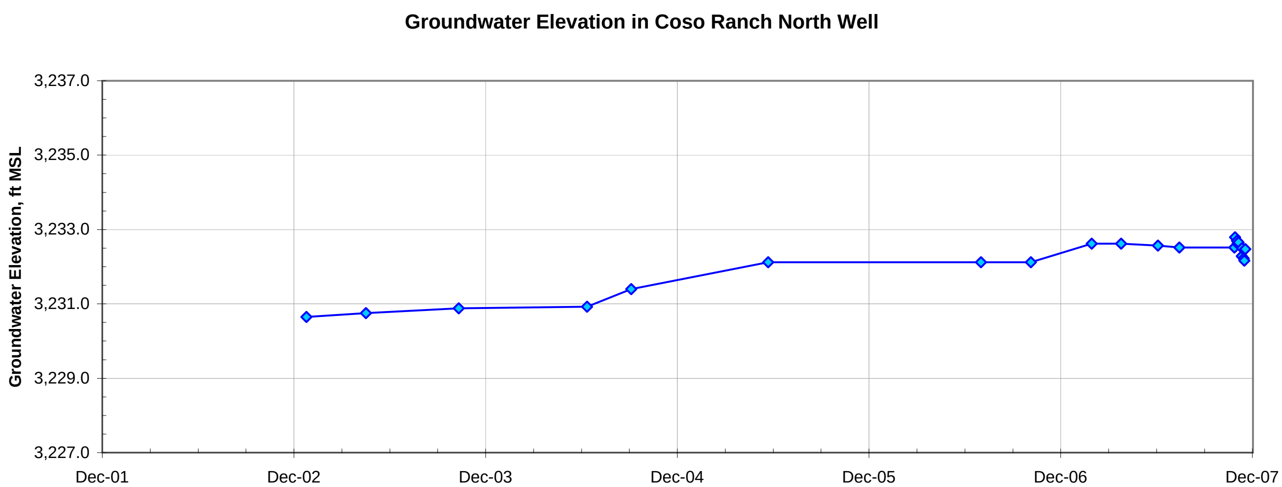
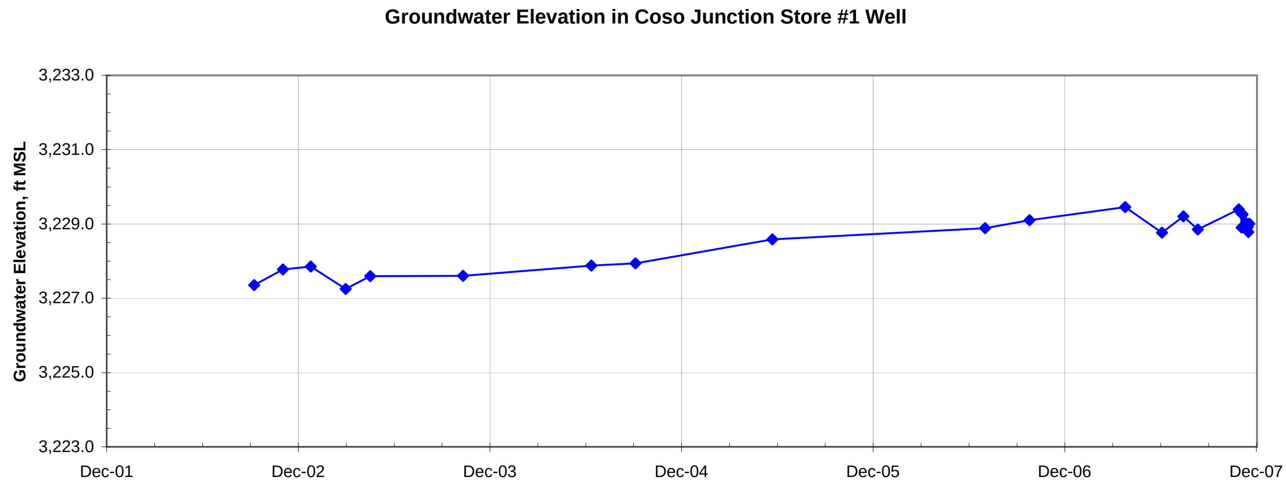
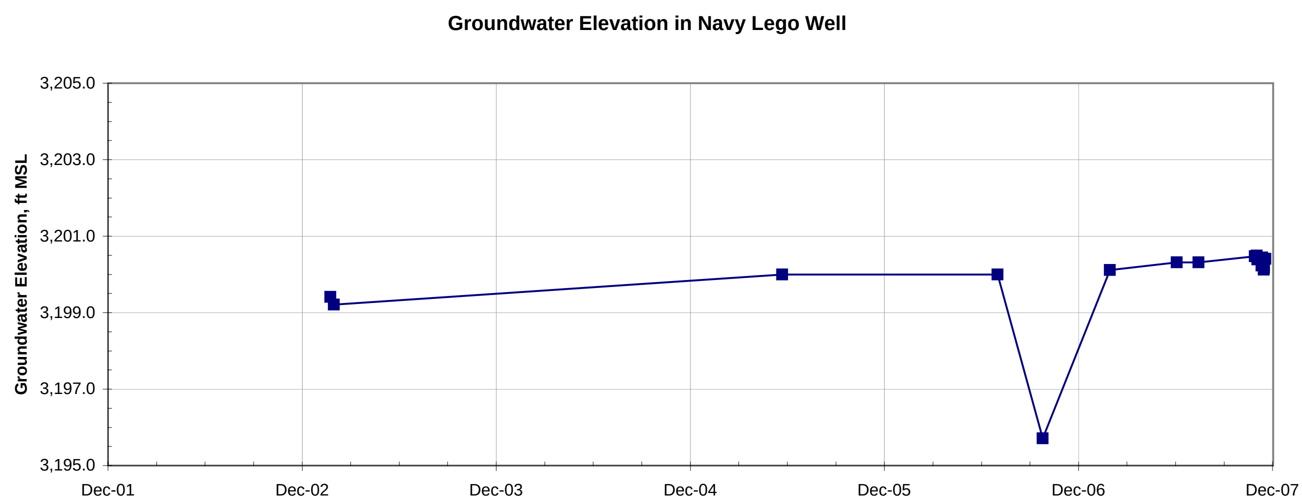


Figure C2-3
Rose Valley Groundwater Level Hydrographs





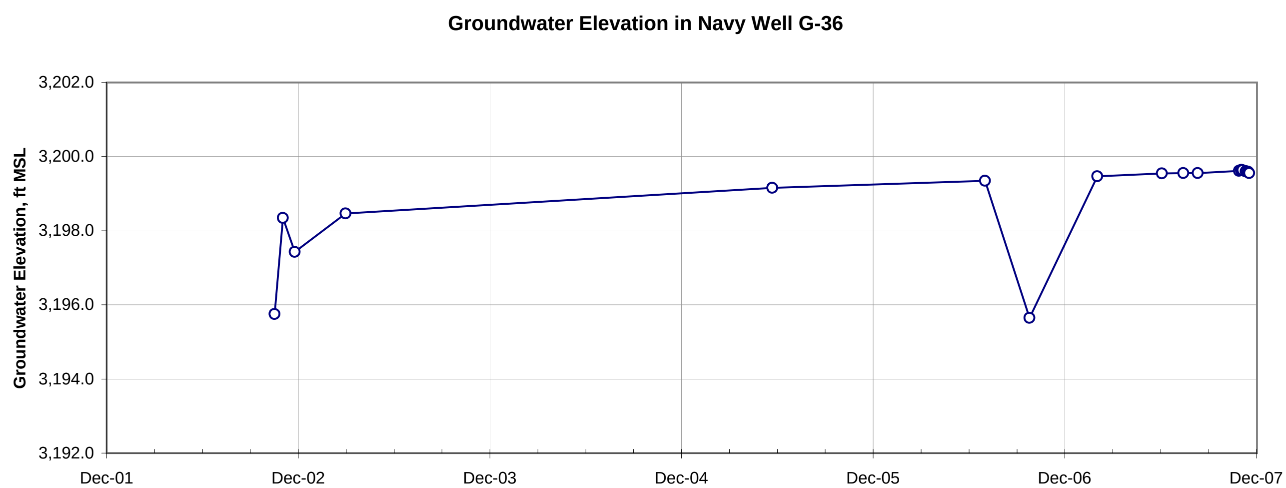
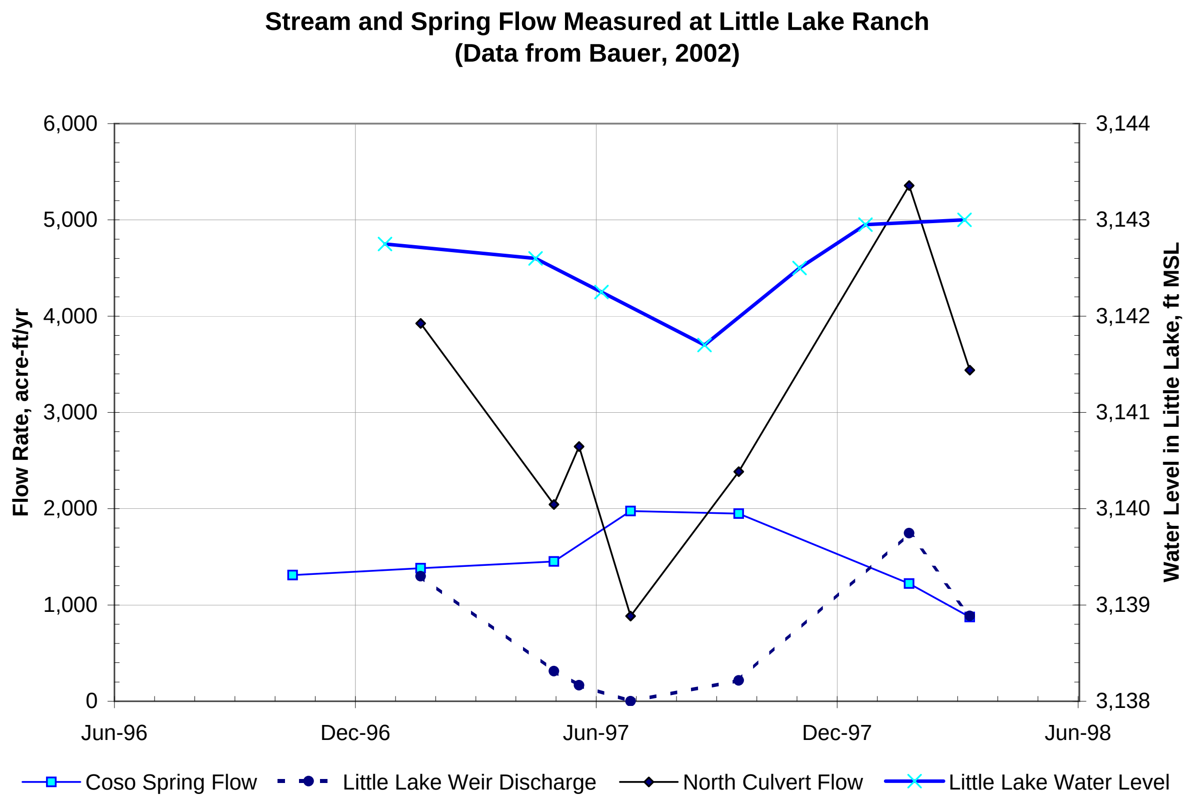
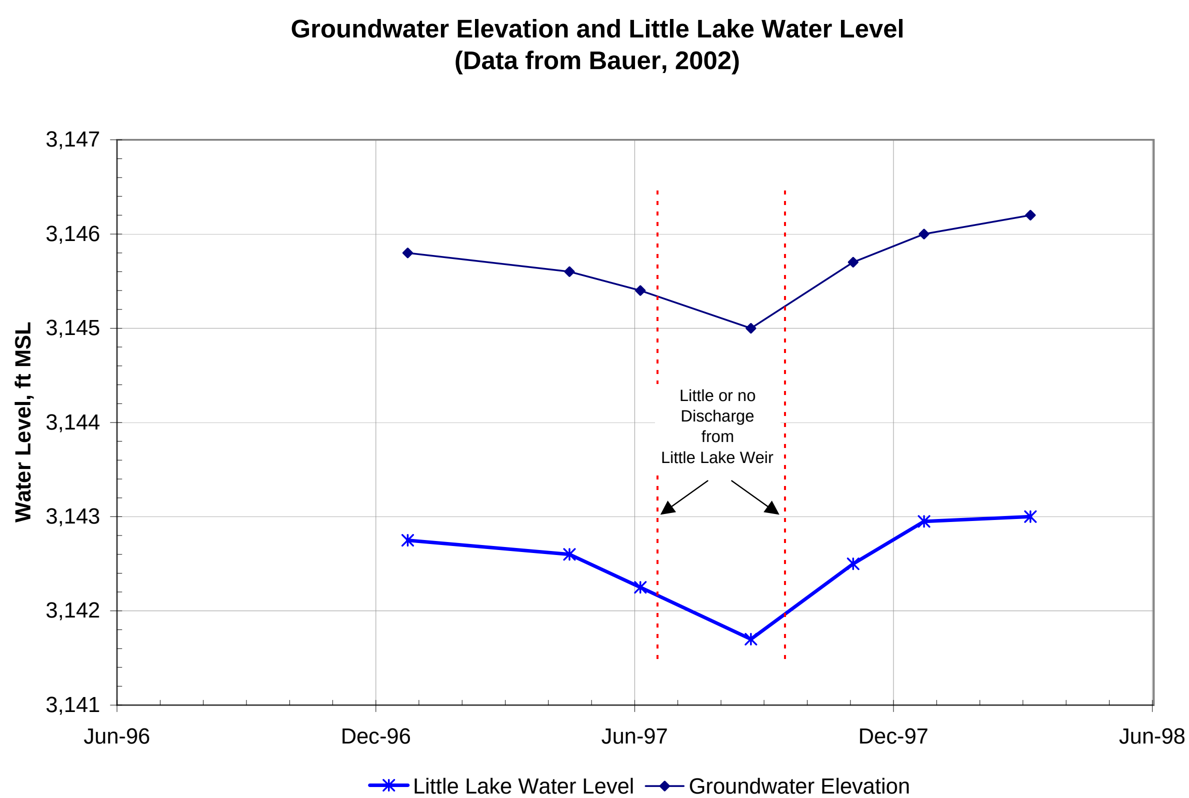
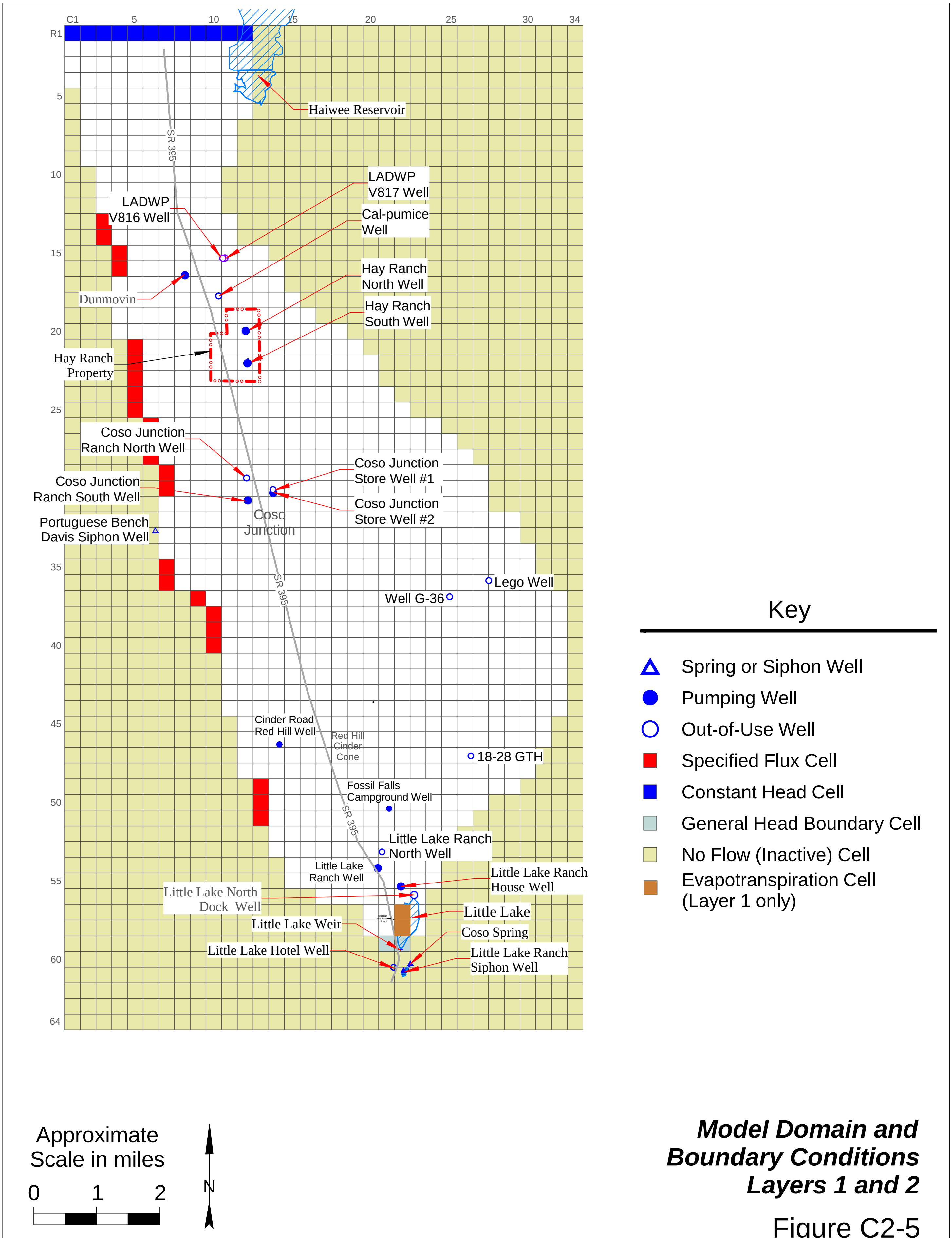


Figure C2-4
Flow and Water Level Measurements at Little Lake

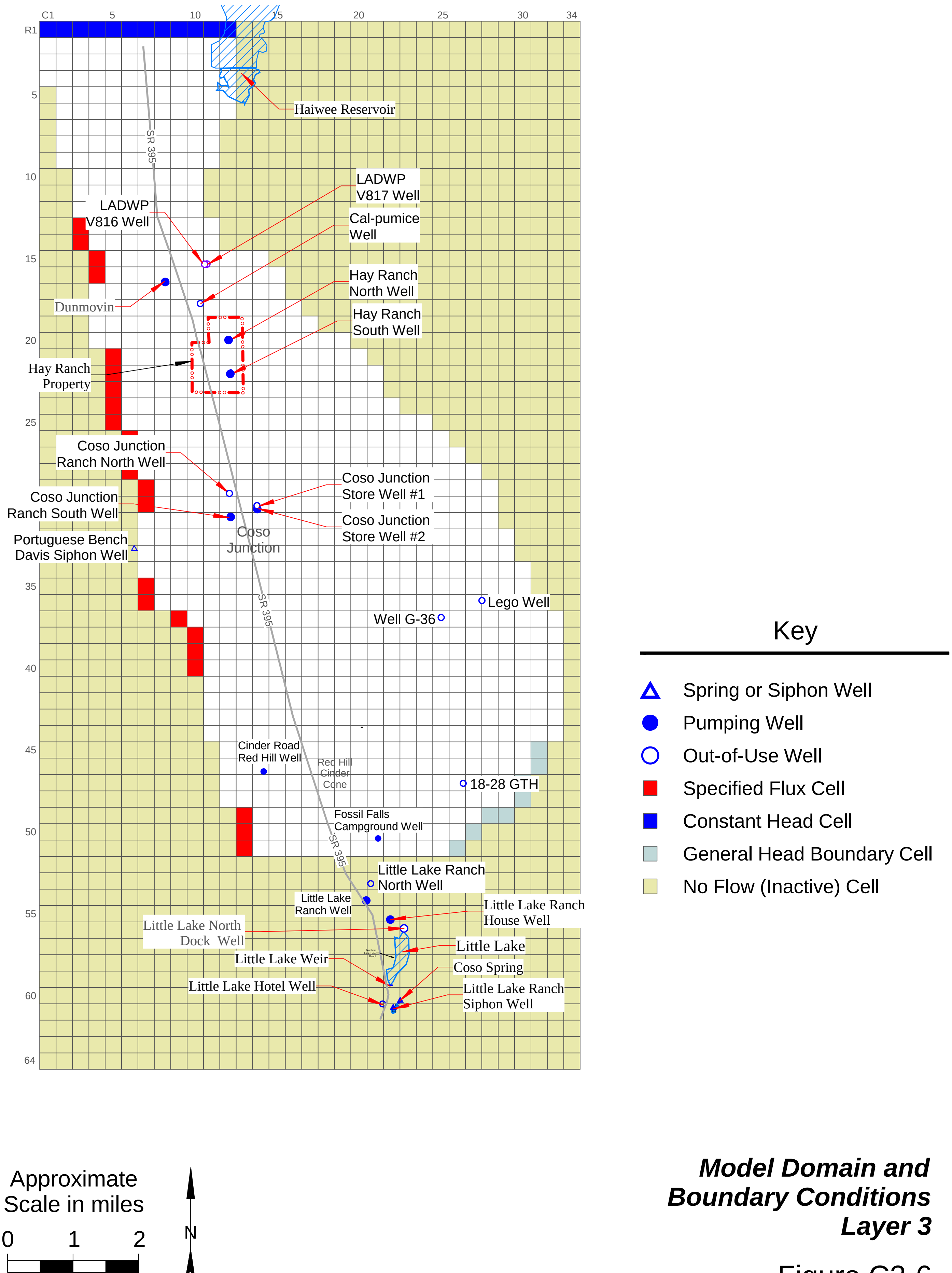






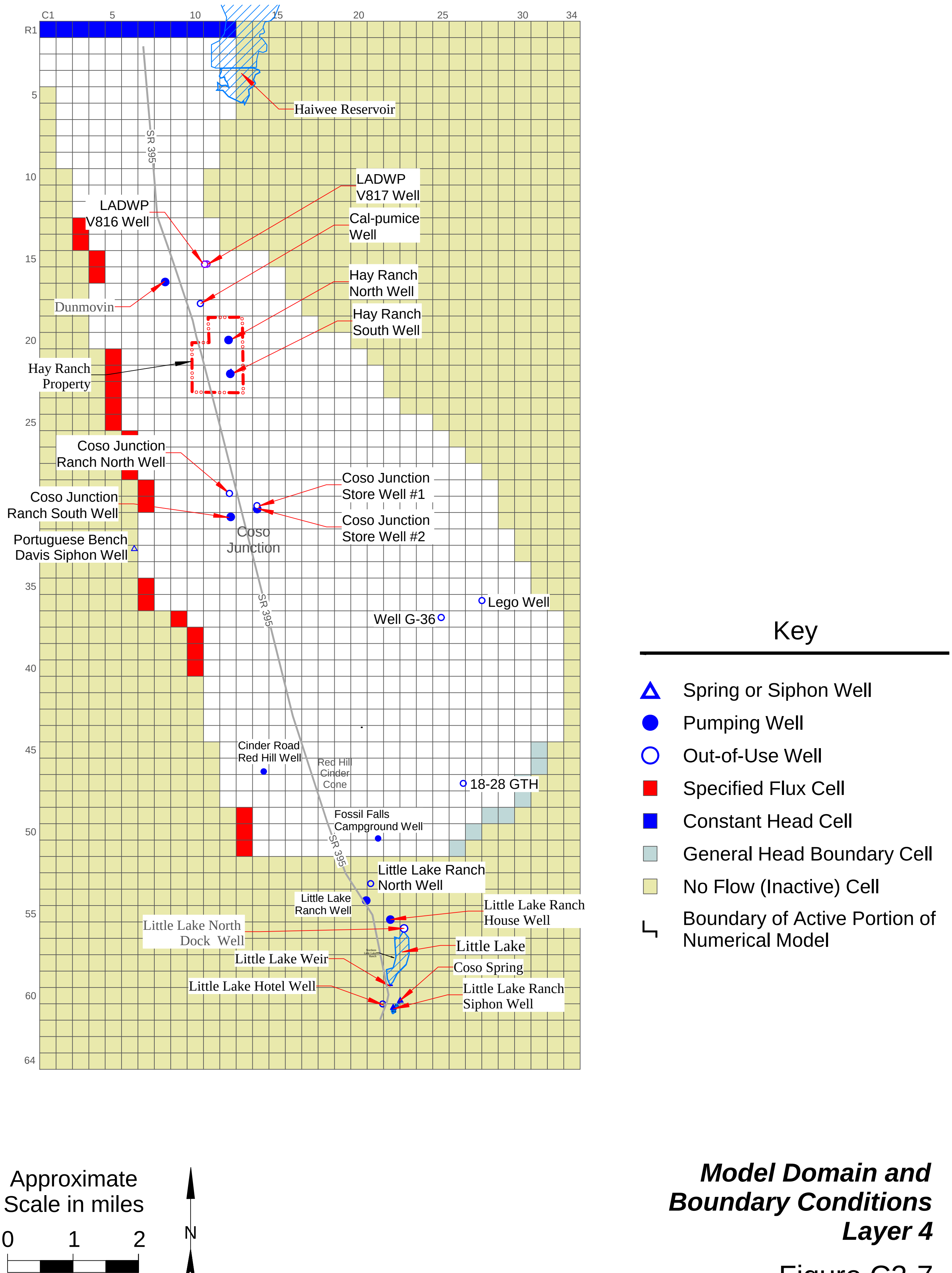
Model Domain and Boundary Conditions Layers 1 and 2

Figure C2-5



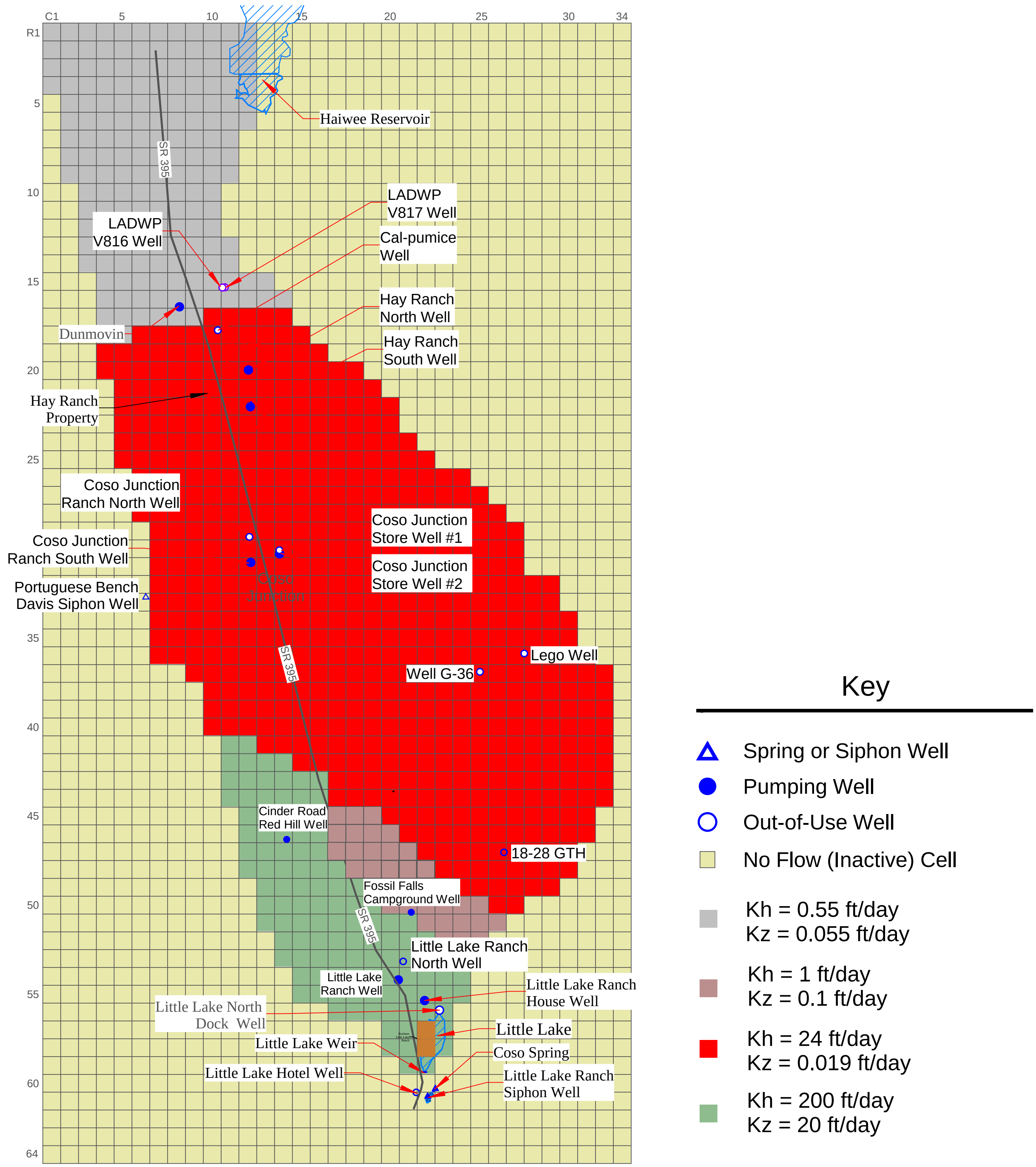
Model Domain and Boundary Conditions Layer 3

Figure C2-6



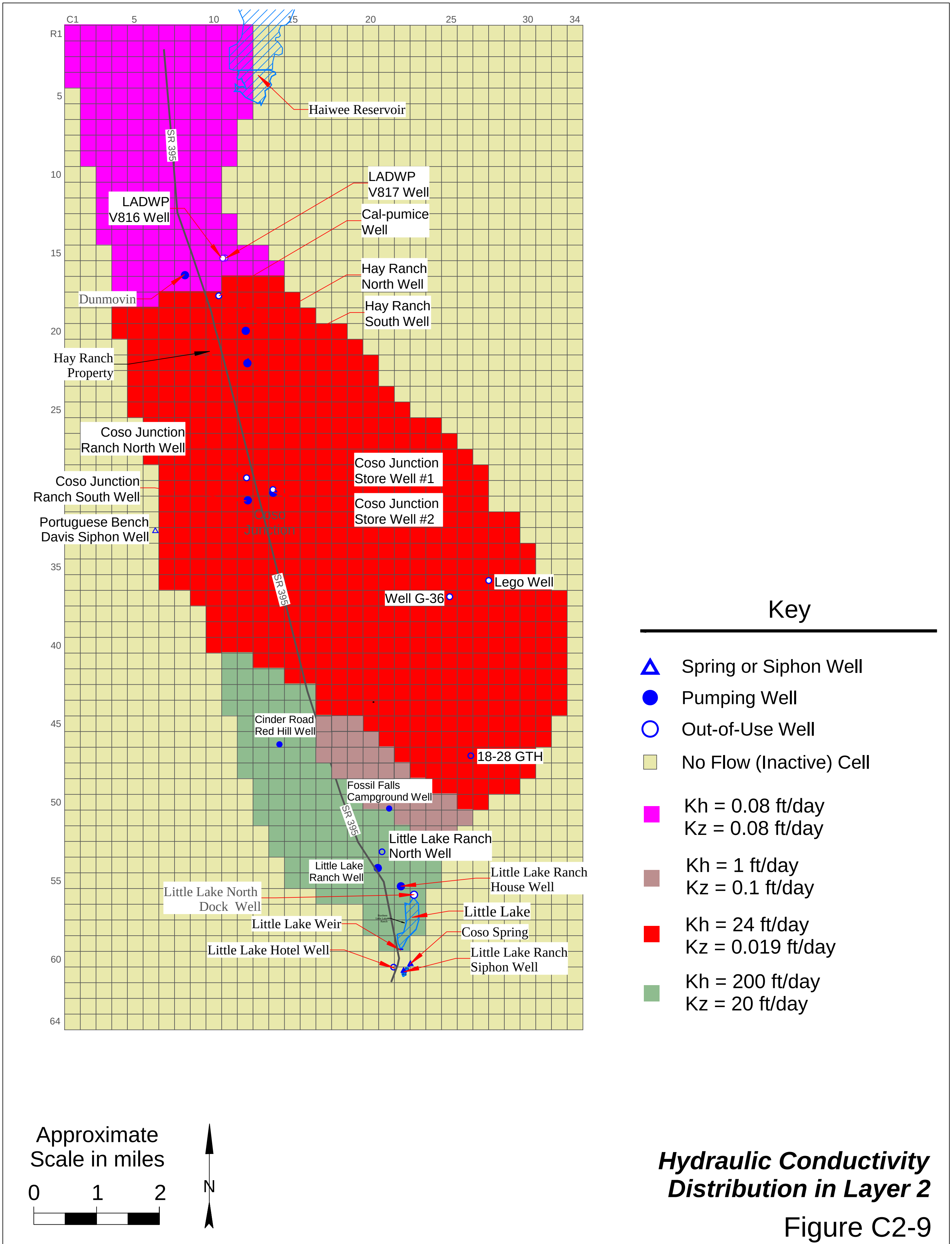
Model Domain and Boundary Conditions Layer 4

Figure C2-7



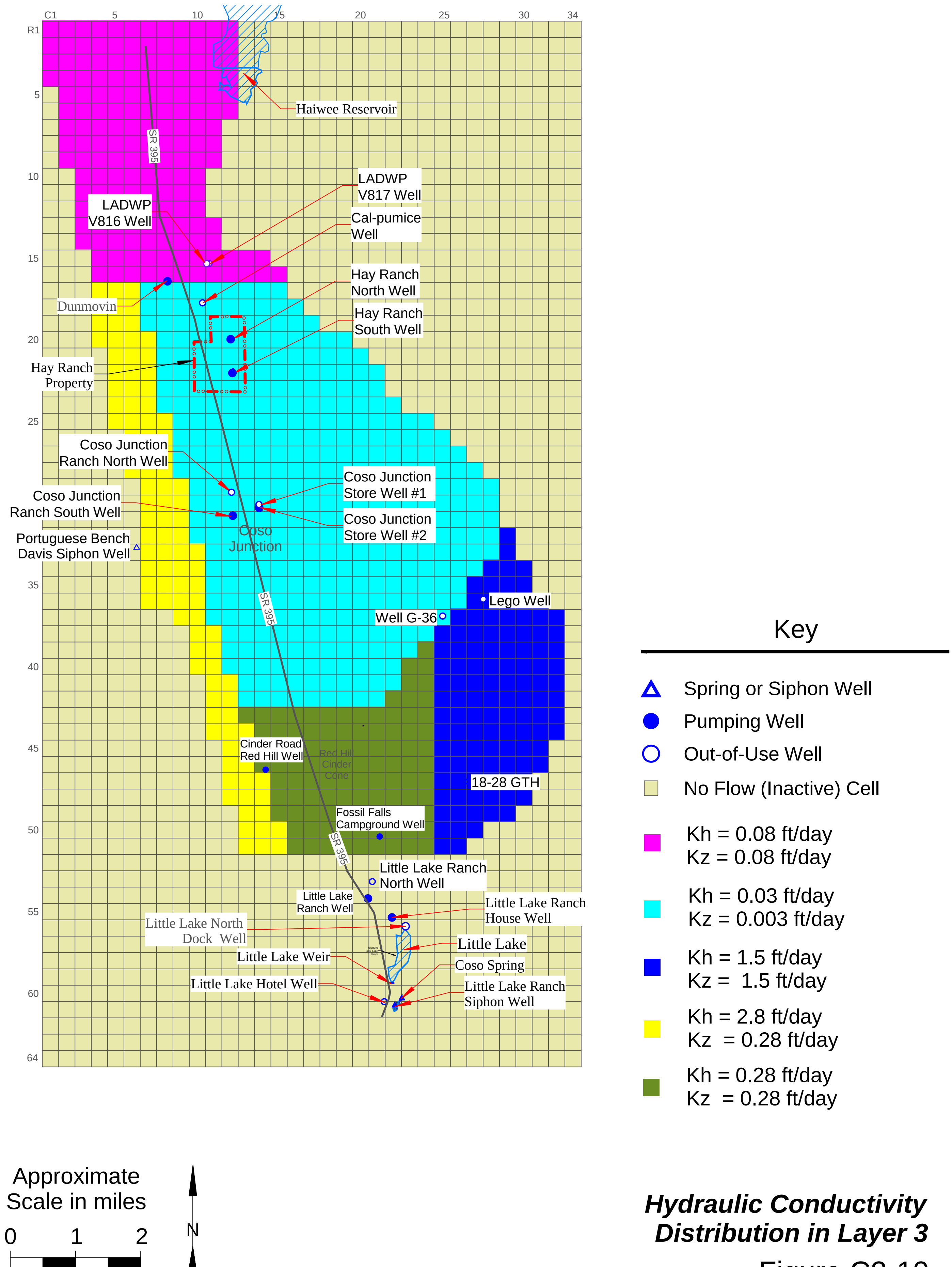
Hydraulic Conductivity Distribution in Layer 1

Figure C2-8



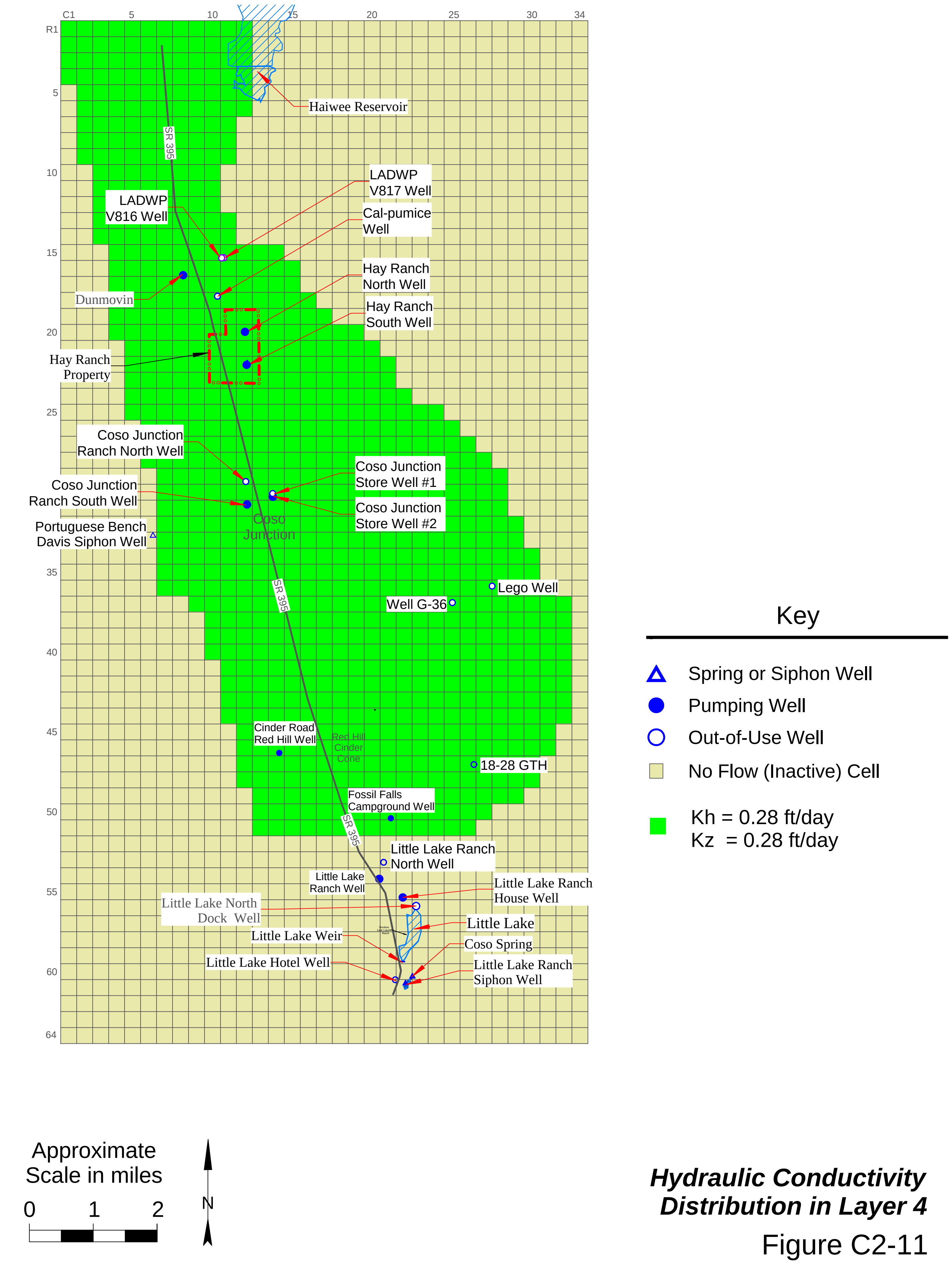
Hydraulic Conductivity Distribution in Layer 2

Figure C2-9



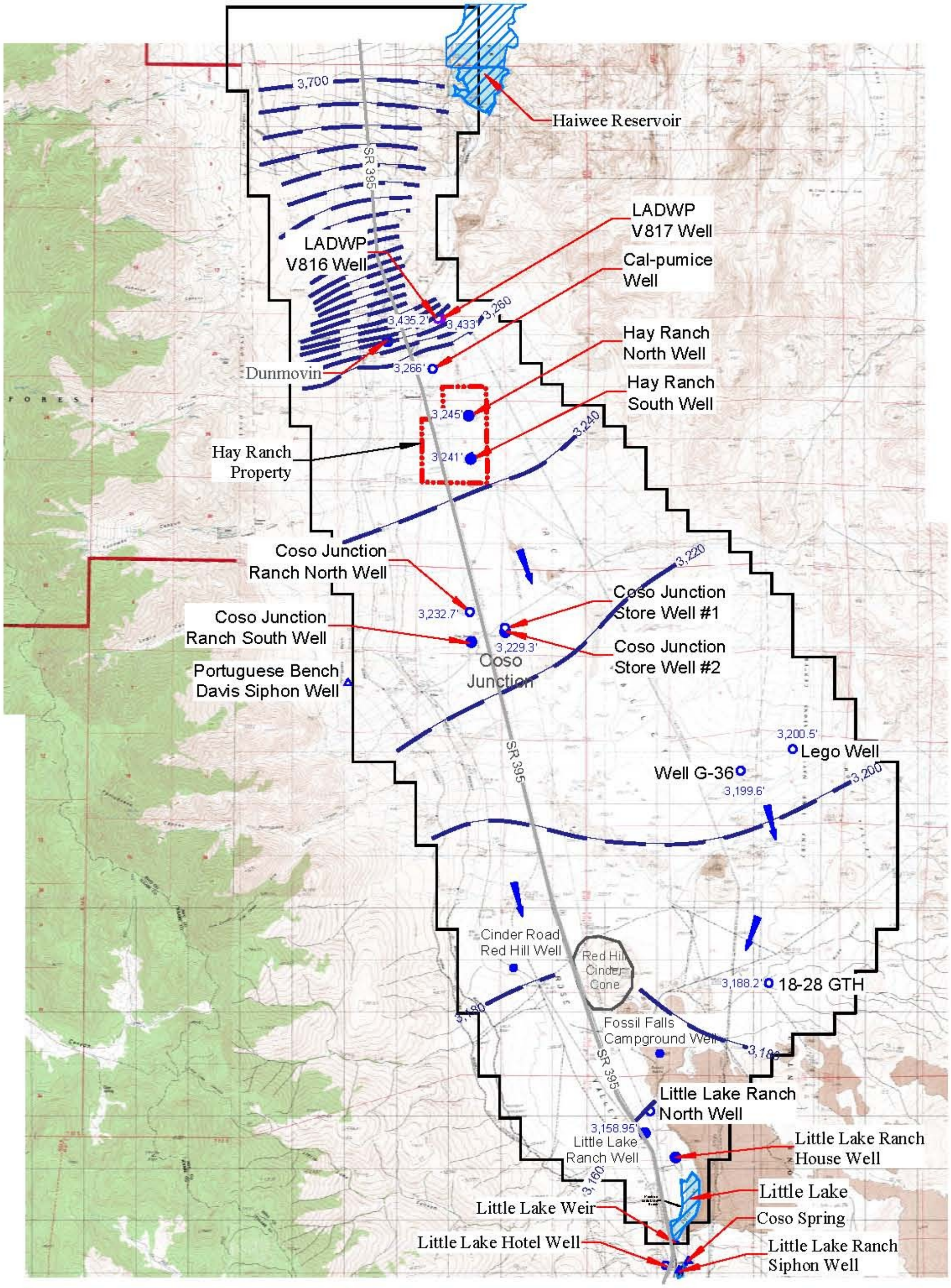
Hydraulic Conductivity Distribution in Layer 3

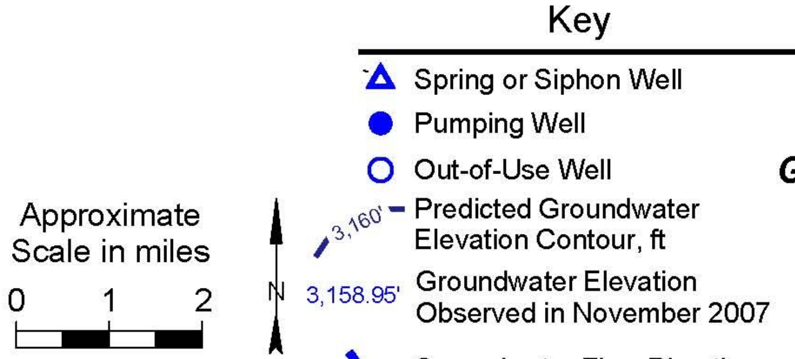
Figure C2-10



Hydraulic Conductivity Distribution in Layer 4

Figure C2-11





Predicted Groundwater Elevation Contours Compared to Groundwater Elevation Observed in November 2007

Figure C2-12

Figure C2-13
Comparison of Simulated versus Observed Groundwater Elevation in Recalibrated Steady-State Numerical Model

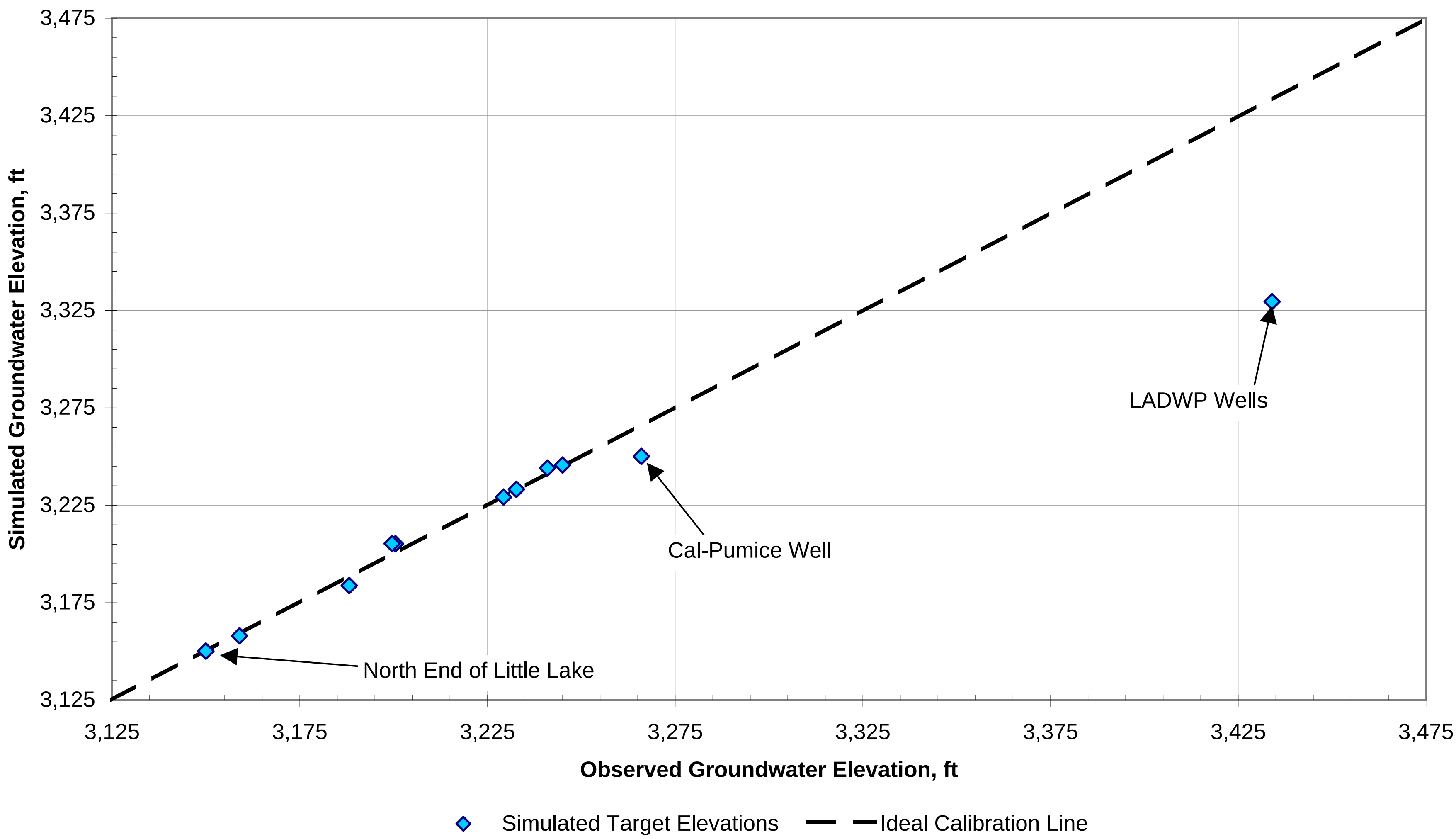
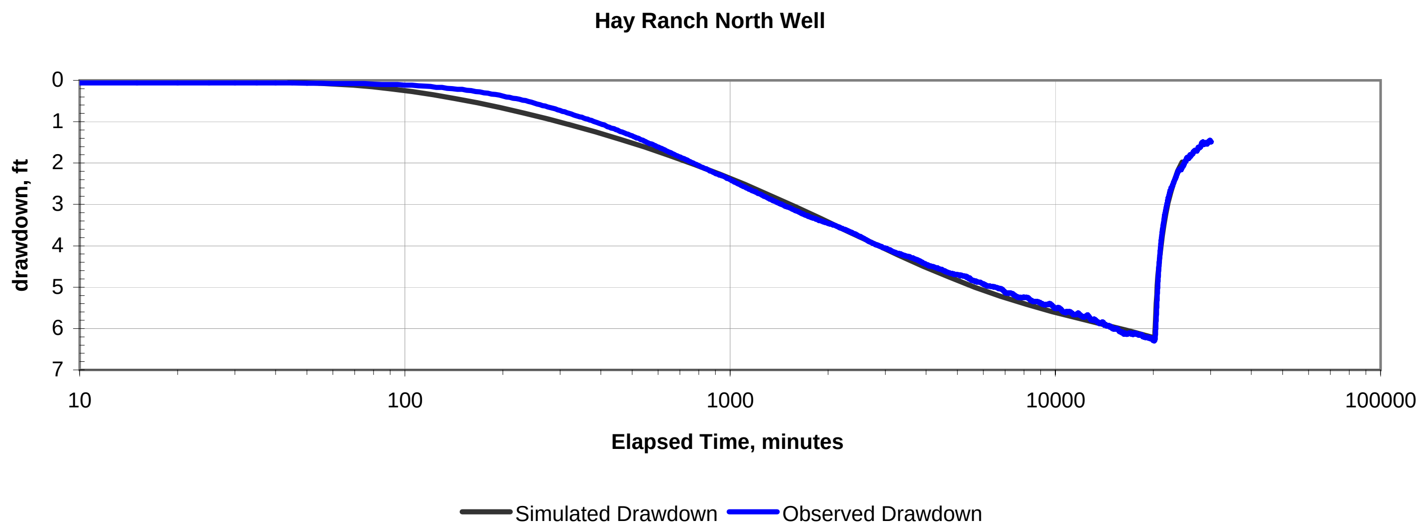
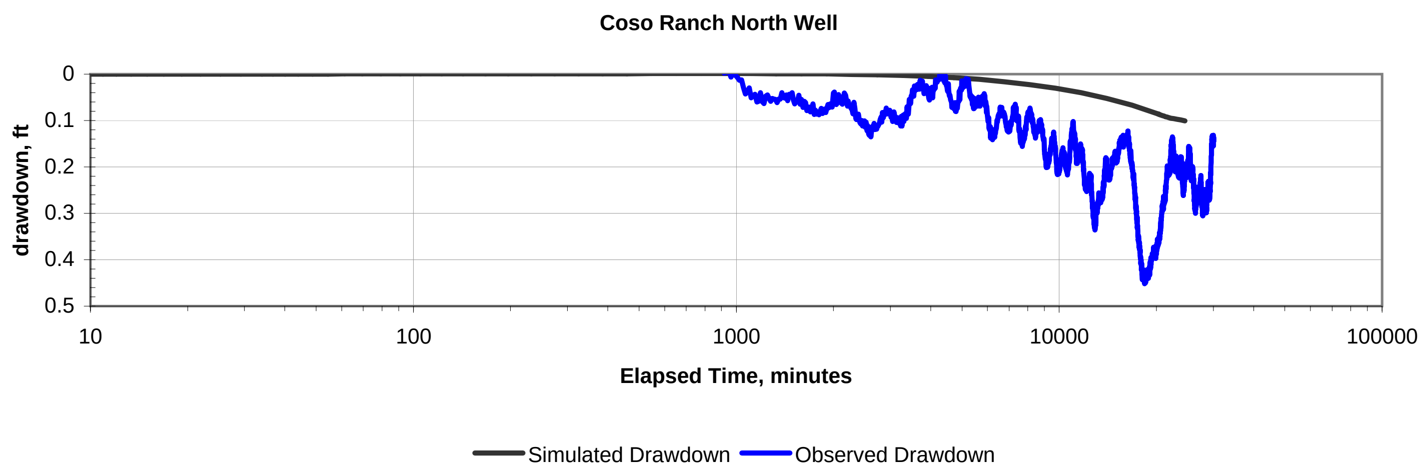
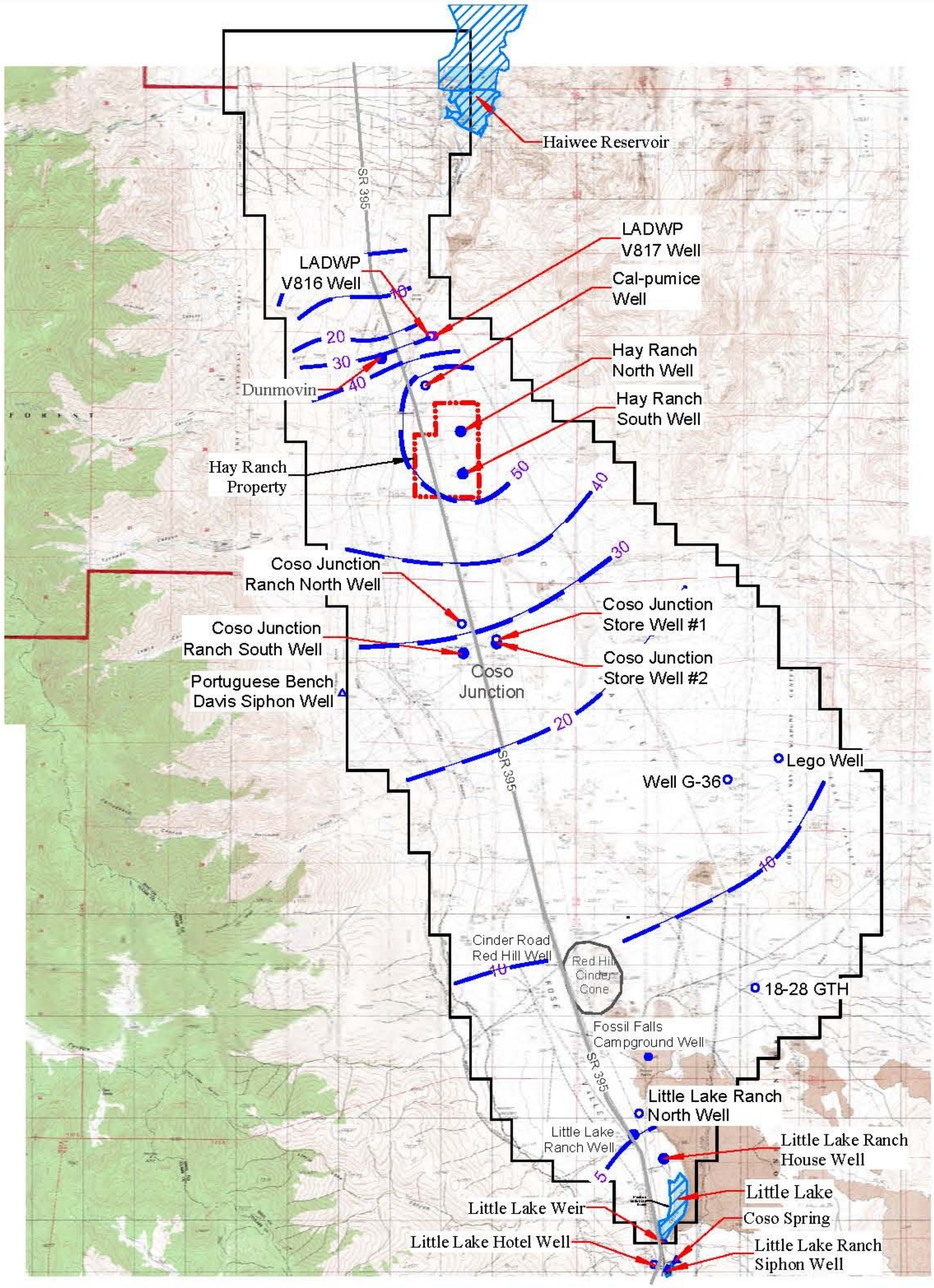


Figure C2-14
Results of Model Calibration to November/December 2007 Pumping Test







Key

- Spring or Siphon Well
- Pumping Well
- Out-of-Use Well
- Groundwater Drawdown Contour, ft
- Boundary of Numerical Model

Predicted Groundwater Table Drawdown after 30 Years at Full Project Development Rate of 4,839 acre-ft/yr

Figure C2-15

Table C2-1
Rose Valley EIR

November 2007 Groundwater Elevation Data
Used for Steady-State Model Calibration Targets

Well	Reference Point Elevation, ft MSL	Depth to Groundwater, ft	Groundwater Elevation, ft
LADWP V816	3,515.35	80.15	3,435.20
LADWP V817	3,511.86	78.86	3,433.00
Cal-Pumice	3,506.38	240.38	3,266.00
Hay Ranch North	3,436.78	191.78	3,245.00
Hay Ranch South	3,420.25	179.35	3,240.90
Coso Junction Store #1	3,372.10	142.80	3,229.30
Coso Ranch North	3,402.72	170.02	3,232.70
G-36	3,379.85	180.25	3,199.60
Lego	3,422.81	222.31	3,200.50
18-28 GTH	3,362.62	174.42	3,188.20
Little Lake Ranch North	3,199.15	40.20	3,158.95

Elevation survey to NGVD 1929 by triad/holme associates.

Table C2-2
Rose Valley EIR

Historic Water Level Monitoring Data

Date	Depth to Groundwater, ft	Groundwater Elevation, ft
Coso Junction Store Well #1		
December 15, 1998	139.00	3,233.10
September 27, 2002	144.75	3,227.35
November 21, 2002	144.33	3,227.77
January 13, 2003	144.25	3,227.85
March 20, 2003	144.85	3,227.25
May 6, 2003	144.51	3,227.59
October 30, 2003	144.50	3,227.60
June 30, 2004	144.22	3,227.88
September 22, 2004	144.16	3,227.94
June 10, 2005	143.52	3,228.58
July 20, 2006	143.22	3,228.88
October 13, 2006	143.00	3,229.10
April 13, 2007	142.65	3,229.45
June 22, 2007	143.34	3,228.76
August 2, 2007	142.90	3,229.20
August 29, 2007	143.25	3,228.85
November 15, 2007	142.71	3,229.39
November 19, 2007	142.80	3,229.30
November 20, 2007	143.20	3,228.90
November 22, 2007	142.85	3,229.25
November 28, 2007	143.15	3,228.95
November 29, 2007	143.09	3,229.01
December 2, 2007	143.18	3,228.92
December 3, 2007	143.32	3,228.78
December 5, 2007	143.10	3,229.00
	Top of casing elevation, ft:	3,372.10
Fossil Falls Campground Well		
October 1, 2002	141.36	--
November 21, 2002	141.42	--
March 20, 2003	141.39	--
June 10, 2005	141.13	--
July 20, 2006	141.25	--
October 13, 2006	141.20	--

Table C2-2
Rose Valley EIR

Historic Water Level Monitoring Data

Date	Depth to Groundwater, ft	Groundwater Elevation, ft
Fossil Falls (continued)		
February 19, 2007	141.25	--
June 22, 2007	141.23	--
August 2, 2007	141.25	--
	Top of casing elevation, ft:	NM
Well G-36 TGH (G-36)		
November 5, 2002	184.10	3,195.75
November 21, 2002	181.50	3,198.35
December 13, 2002	182.42	3,197.43
March 20, 2003	181.38	3,198.47
June 10, 2005	180.69	3,199.16
July 20, 2006	180.50	3,199.35
October 13, 2006	184.20	3,195.65
February 19, 2007	180.38	3,199.47
June 22, 2007	180.30	3,199.55
August 2, 2007	180.29	3,199.56
August 29, 2007	180.29	3,199.56
November 15, 2007	180.23	3,199.62
November 19, 2007	180.22	3,199.63
November 20, 2007	180.21	3,199.64
November 22, 2007	180.22	3,199.63
November 28, 2007	180.25	3,199.60
November 29, 2007	180.24	3,199.61
December 2, 2007	180.26	3,199.59
December 3, 2007	180.26	3,199.59
December 5, 2007	180.29	3,199.56
	Top of casing elevation, ft:	3,379.85

Table C2-2
Rose Valley EIR

Historic Water Level Monitoring Data

Date	Depth to Groundwater, ft	Groundwater Elevation, ft
Hay Ranch North Well		
December 15, 1998	199.00	3,237.78
September 30, 2002	193.75	3,243.03
November 21, 2002	193.85	3,242.93
January 13, 2003	193.75	3,243.03
March 20, 2003	192.26	3,244.52
December 9, 2003	193.20	3,243.58
June 30, 2004	193.00	3,243.78
September 22, 2004	192.91	3,243.87
June 10, 2005	192.32	3,244.46
July 20, 2006	192.62	3,244.16
October 13, 2006	192.29	3,244.49
February 16, 2007	192.30	3,244.48
April 13, 2007	192.15	3,244.63
June 22, 2007	191.65	3,245.13
August 2, 2007	191.60	3,245.18
November 14, 2007	191.68	3,245.10
November 15, 2007	191.65	3,245.13
November 19, 2007	191.60	3,245.18
November 20, 2007	194.30	3,242.48
November 22, 2007	196.08	3,240.70
November 28, 2007	197.61	3,239.17
November 29, 2007	197.56	3,239.22
December 2, 2007	198.07	3,238.71
December 3, 2007	198.32	3,238.46
December 5, 2007	194.14	3,242.64
December 17, 2007	192.72	3,244.06
	Top of casing elevation, ft:	3,436.78
Hay Ranch South Well		
December 15, 1998	182.00	3,238.25
September 30, 2002	181.62	3,238.63
November 21, 2002	181.46	3,238.79
January 13, 2003	181.25	3,239.00
March 20, 2003	181.10	3,239.15
May 6, 2003	180.80	3,239.45

Table C2-2
Rose Valley EIR

Historic Water Level Monitoring Data

Date	Depth to Groundwater, ft	Groundwater Elevation, ft
Hay Ranch South (continued)		
December 9, 2003	181.34	3,238.91
June 30, 2004	180.95	3,239.30
September 22, 2004	180.76	3,239.49
June 10, 2005	180.15	3,240.10
July 20, 2006	179.64	3,240.61
October 13, 2006	179.40	3,240.85
April 13, 2007	179.50	3,240.75
June 22, 2007	179.00	3,241.25
August 2, 2007	178.98	3,241.27
August 29, 2007	179.35	3,240.90
November 15, 2007	179.35	3,240.90
November 19, 2007	179.35	3,240.90
	Top of casing elevation, ft:	3,420.25
Coso Ranch North Well		
January 13, 2003	172.07	3,230.65
May 6, 2003	171.97	3,230.75
October 30, 2003	171.84	3,230.88
June 30, 2004	171.80	3,230.92
September 22, 2004	171.32	3,231.40
June 10, 2005	170.60	3,232.12
July 20, 2006	170.60	3,232.12
October 23, 2006	170.60	3,232.12
February 16, 2007	170.10	3,232.62
April 13, 2007	170.10	3,232.62
June 22, 2007	170.15	3,232.57
August 2, 2007	170.20	3,232.52
November 14, 2007	170.20	3,232.52
November 15, 2007	169.93	3,232.79
November 19, 2007	170.02	3,232.70
November 20, 2007	170.10	3,232.62
November 22, 2007	170.07	3,232.65
November 28, 2007	170.44	3,232.28

Table C2-2
Rose Valley EIR

Historic Water Level Monitoring Data

Date	Depth to Groundwater, ft	Groundwater Elevation, ft
Coso Ranch North (continued)		
November 29, 2007	170.22	3,232.50
December 2, 2007	170.50	3,232.22
December 3, 2007	170.56	3,232.16
December 5, 2007	170.25	3,232.47
	Top of casing elevation, ft:	3,402.72
LADWP Well V817 (LADWP #1)		
June 30, 2004	72.90	3,438.96
September 22, 2004	77.63	3,434.23
June 10, 2005	79.70	3,432.16
July 20, 2006	77.70	3,434.16
October 13, 2006	78.09	3,433.77
February 16, 2007	76.70	3,435.16
April 13, 2007	76.45	3,435.41
June 22, 2007	77.15	3,434.71
August 2, 2007	76.63	3,435.23
August 29, 2007	77.15	3,434.71
November 15, 2007	78.70	3,433.16
November 19, 2007	78.81	3,433.05
November 20, 2007	78.82	3,433.04
November 22, 2007	78.88	3,432.98
November 28, 2007	79.07	3,432.79
November 29, 2007	79.00	3,432.86
December 2, 2007	79.17	3,432.69
December 3, 2007	79.17	3,432.69
December 5, 2007	79.06	3,432.80
	Top of casing elevation, ft:	3,511.86

Table C2-2
Rose Valley EIR

Historic Water Level Monitoring Data

Date	Depth to Groundwater, ft	Groundwater Elevation, ft
LADWP Well V816 (LADWP #2)		
May 6, 2003	77.08	3,438.27
October 30, 2003	79.14	3,436.21
June 10, 2005	80.80	3,434.55
July 20, 2006	78.85	3,436.50
October 13, 2006	77.01	3,438.34
February 19, 2007	75.42	3,439.93
April 13, 2007	75.35	3,440.00
June 22, 2007	76.00	3,439.35
August 2, 2007	77.82	3,437.53
August 29, 2007	78.30	3,437.05
November 14, 2007	80.20	3,435.15
November 15, 2007	80.20	3,435.15
November 19, 2007	80.14	3,435.21
November 20, 2007	80.16	3,435.19
November 22, 2007	80.18	3,435.17
November 28, 2007	80.34	3,435.01
November 29, 2007	80.31	3,435.04
December 2, 2007	80.46	3,434.89
December 3, 2007	80.43	3,434.92
December 5, 2007	80.39	3,434.96
	Top of casing elevation, ft:	3,515.35
Lego Well		
February 11, 2003	223.40	3,199.41
February 18, 2003	223.60	3,199.21
June 10, 2005	222.82	3,199.99
July 20, 2006	222.82	3,199.99
October 13, 2006	227.10	3,195.71
February 16, 2007	222.70	3,200.11
June 22, 2007	222.50	3,200.31
August 2, 2007	222.50	3,200.31
November 15, 2007	222.34	3,200.47
November 19, 2007	222.32	3,200.49
November 20, 2007	222.42	3,200.39
November 22, 2007	222.41	3,200.40

Table C2-2
Rose Valley EIR

Historic Water Level Monitoring Data

Date	Depth to Groundwater, ft	Groundwater Elevation, ft
Lego (continued)		
November 28, 2007	222.58	3,200.23
November 29, 2007	222.37	3,200.44
December 2, 2007	222.69	3,200.12
December 3, 2007	222.63	3,200.18
December 5, 2007	222.41	3,200.40
	Top of casing elevation, ft:	3,422.81
Cal-Pumice (Pumice Mine) Well		
December 15, 1998	242.00	3,264.38
June 30, 2004	241.52	3,264.86
September 22, 2004	241.24	3,265.14
June 10, 2005	240.91	3,265.47
July 20, 2006	240.74	3,265.64
October 23, 2006	240.73	3,265.65
February 16, 2007	241.70	3,264.68
April 13, 2007	240.60	3,265.78
June 22, 2007	240.00	3,266.38
August 2, 2007	239.98	3,266.40
August 29, 2007	240.00	3,266.38
November 14, 2007	240.31	3,266.07
November 15, 2007	240.30	3,266.08
November 19, 2007	240.42	3,265.96
November 20, 2007	240.40	3,265.98
November 22, 2007	240.50	3,265.88
November 28, 2007	240.83	3,265.55
November 29, 2007	240.52	3,265.86
December 2, 2007	241.14	3,265.24
December 3, 2007	241.05	3,265.33
December 5, 2007	240.38	3,266.00
	Top of casing elevation, ft:	3,506.38

NM - Not surveyed, elevation cannot be calculated.
Elevation survey to NGVD 1929 by triad/holme associates.

Table C2-3
Rose Valley EIR

Summary of Bauer (2002) Stream and Spring Flow Measurements

Location	Date Measured	Instantaneous Flow Rate, acre-ft/yr
Coso Spring	10/28/1996	1,311
South Culvert(1)	10/28/1996	318
Coso Spring	2/2/1997	1,382
Little Lake Weir	2/2/1997	1,299
North Culvert(2)	2/2/1997	3,924
South Culvert	2/2/1997	515
Coso Spring	5/14/1997	1,451
Little Lake Weir	5/14/1997	312
North Culvert	5/14/1997	2,043
South Culvert	5/14/1997	583
Little Lake Weir	6/2/1997	166
North Culvert	6/2/1997	2,646
South Culvert	6/2/1997	676
Coso Spring	7/11/1997	1,976
Little Lake Weir	7/11/1997	0
North Culvert	7/11/1997	885
South Culvert	7/11/1997	428
Coso Spring	10/1/1997	1,949
Little Lake Weir	10/1/1997	217
North Culvert	10/1/1997	2,384
South Culvert	10/1/1997	627
Coso Spring	2/7/1998	1,222
Little Lake Weir	2/7/1998	1,746
North Culvert	2/7/1998	5,357
South Culvert	2/7/1998	1,866
Coso Spring	3/25/1998	874
Little Lake Weir	3/25/1998	887
North Culvert	3/25/1998	3,439
South Culvert	3/25/1998	917

Notes:

(1) Most southerly surface water flow measurement point on the property.

(2) Flow rate in ditch discharging from lower Little Lake pond (P-2); contains combined flow from Little Lake Weir, Coso Spring, and siphon well.

Appendix C3 - Hydrogeochemical Data

Geochemical Database for Rose Valley Hydrological Sysyem Based on Guler, 2002 with Additional Data

SITE NAME	LATITUDE	LONGITUDE	DATE	TEMP	ALK	HARDNESS	COND	pH	Ca	Mg	Na	K	Cl	SO4	HCO3	SiO2	Cl/B	B	Br	Deuterium ‰	Oxygen-18 ‰	TDS	TDS(sum)	BALANCE	DATA SOURCE
WILD ROSE RANCH SPRING	360245	1175833	790400	5.00	232.79	209.94	-9999	7.70	66.00	11.00	24.00	4.00	9.0	37.0	284.0	30.0	45.0	0.20		-102.0	-13.9	465	465	-3.16	10
TUNAWEE CANYON SPRING, SIERRA NEVADA	360349	1180000	970521	16.60	312.00	266.46	620	8.13	77.11	18.00	26.99	4.50	8.6	35.9	343.0	26.2	107.5	0.08	0.050			230	540	3.92	5
SOUTH KENNEDY MEADOWS (GOVERNMENT SPRING)	355818	1180529	960824	22.60	242.00	214.74	525	7.80	57.70	17.20	18.30	3.71	8.8	49.7	256.0	28.9	175.8	0.05	0.040	-105.0	-13.7	331	440	-2.87	25
SOUTH FORK KERN RIVER "1"	361000	1180620	960331	7.78	59.40	37.15	138	8.47	10.70	2.54	11.10	1.78	7.9	3.0	54.2	20.3	98.4	0.08	0.007	-108.0	-14.7	84	112	3.90	5
SACATAR CANYON SPRING	355842	1180259	960824	22.00	285.00	180.19	501	7.90	48.80	14.20	21.80	3.91	12.3	29.8	252.0	25.9	246.0	0.05	0.040	-110.0	-14.4	293	409	-4.77	25
S. NEV. FAULT	355730	1175610	950517	16.20	167.21	272.44	-9999	7.40	80.00	17.70	58.00	7.10	45.4	161.0	204.0	23.0		0.05	0.240	-101.0	-12.5	505	596	0.37	5
ROUND MEADOW	355806	1182110	960727	14.70	12.00	16.30	56	6.90	5.13	0.85	2.50	0.22	0.2	0.4	22.9	16.6	4.4	0.05	0.040	-95.0	-12.7	46	49	5.44	25
ROCK HOUSE SPRING	355310	1181211	960825	25.30	162.00	56.83	330	7.80	20.80	1.20	50.10	0.76	2.6	8.1	186.0	53.7	52.0	0.05	0.040	-102.0	-13.7	240	323	-1.37	25
RED HILL WELL, ROSE VALLEY	355903	1175630	980515	19.00	204.00	177.65	570	7.53	46.33	15.08	44.04	6.51	25.3	8.2	346.0	0.0	361.4	0.07	0.510			492	492	-0.13	5
Fossil Falls																				-103.0	-13.7				GeoTrans 2004
PROTUGESE BENCH SPRING, ROSE VALLEY	360244	1175826	970602	20.00	190.00	196.50	450	7.73	61.49	10.47	17.81	3.37	5.1	26.9	248.8	25.0	96.2	0.05	0.030			399	399	-0.09	5
Portugese Bench-new			71213										5.8				52.7	0.11		-100.1	-13.9	280			Coso 07
PHIL HENNIS RANCH WELL	360500	1175704	790400	22.5	250.00	292.50	-9999	7.20	76.00	25.00	109.00	10.20	65.0	140.0	305.0	42.0	68.4	0.95		-112.0	-14.5	774	773	5.23	10
LADPW																				-111.8	-14.5				GeoTrans, 04
Rose Valley Rnch	360458	115703	790400					8.13	111.00	28	114.00	11.00	75.0	200.0	256.0	30.0	75.0	1.00		-109.0	-13.8	827	826		10
Rose Valley Rnch	360458	115703	790400					7.93	110.00	28	120.00	11.00	70.0	190.0	261.0	33.0	70.0	1.00		-111.0	-13.9	825	824		10
Rose Valley Rnch	360458	115703	790400					7.8	109.00	28	118.00	10.00	72.0	200.0	248.0	31.0	90.0	0.80		-109.0	-14.2	817	817		10
Hay Ranch North			2002						96.30	36.00	133.00	9.38	79.0	329.0	250.0					-107.8	-14.4	945	933		GeoTrans, 04
Hay Ranch South			2002						113.00	37.70	111.00	11.80	75.7	251.0	320.0							844	920		GeoTrans, 04
Hay Ranch South-new			71213										73.0				56.2	1.30		-107.5	-14.3	820			Coso 07
LEGO									91.10	64.40	685.00	20.10	898.0	94.9	346.0	28.8	707.1	1.27		-103.8	-10.3	2540	2230		
18-29GTH					1183.00			8.42	34.20	47.19	614.40	43.36	514.2	61.7	1183.0	108.0	13.4	38.25	4.880			2045	2098	2.44	Navy, 2007
MOSQUITO MEADOW	355624	1182043	960728	18.9	18.00	18.33	64	7.10	5.02	1.41	3.80	1.23	0.6	1.3	27.6	21.6	11.0	0.05	0.040	-105.0	-13.6	53	63	6.06	25
LL-W4 LITTLE LAKE	355615	1175355	951017	21.4	392.62	410.93	1580	8.17	75.80	53.90	223.00	26.10	188.0	106.0	479.0	53.3	32.9	5.71	0.550	-104.0	-13.6	978	1211	9.42	5
LL-W4 LITTLE LAKE	355615	1175355	950506	19.6	639.00	429.18	-9999	7.20	78.00	57.00	256.00	22.00	108.0	182.0	780.0	66.0	20.8	5.20	0.420	-106.0	-12.5	1150	1554	1.56	5
LL-W3 LITTLE LAKE	355728	1175400	951017	25.9	510.66	395.17	1260	7.57	93.40	39.40	151.00	17.80	48.4	69.8	623.0	52.4	21.1	2.29	0.310	-98.0	-12.4	901	1097	6.67	5
LL-W3 LITTLE LAKE	355728	1175400	950506	24.3	631.00	400.76	-9999	7.00	93.00	41.00	167.00	14.60	79.0	49.7	770.0	64.0	37.6	2.10	0.160	-107.0	-14.1	890	1280	-0.83	5
LL-W3 LITTLE LAKE	355728	1175400	940915	24.1	660.00	420.00	1400	7.30	98.00	42.00	160.00	11.00	52.0	81.0	810.0	75.0	28.9	1.80		-107.0	-13.9	920	1331	-2.89	5
LL-W2 LITTLE LAKE	355730	1175405	951017	22.3	300.82	295.80	1300	8.04	66.60	31.50	166.00	23.40	158.0	96.3	367.0	46.1	39.1	4.04	0.500	-104.0	-14.2	837	959	4.69	5
LL-W2 LITTLE LAKE	355730	1175405	950506	18.6	418.00	350.86	-9999	7.70	73.00	41.00	228.00	22.00	127.0	211.0	510.0	61.0	25.9	4.90	0.520	-108.0	-13.4	1120	1278	3.34	5
LL-W2 LITTLE LAKE	355730	1175405	940915	21.4	370.00	300.00	1300	8.10	65.00	33.00	160.00	20.00	160.0	100.0	450.0	69.0	55.2	2.90		-103.0	-13.3	830	1060	-2.22	5
LL-W1 LITTLE LAKE	355726	1175349	950504	23.9	1430.00	820.35	1570	7.30	182.00	89.00	434.00	29.00	108.0	192.0	1750.0	76.0	9.8	11.00	0.410			2010	2871	0.37	5
LL-W1 LITTLE LAKE	355726	1175349	940915	23.1	1700.00	970.00	3300	6.90	220.00	100.00	460.00	34.00	220.0	120.0	2100.0	110.0	20.0	11.00				2300	3375	-3.89	5
LL-SPG-2 LITTLE LAKE	355655	1175404	951017	20.2	346.72	296.75	983	7.12	68.30	30.70	116.00	12.80	69.0	82.3	423.0	35.9	33.5	2.06	0.370	-101.0	-12.4	621	840	3.04	5
LL-S2 LITTLE LAKE	355610	1175402	951007	17.1	450.82	365.16	1730	8.15	46.90	60.30	256.00	27.40	194.0	106.0	550.0	50.8	30.1	6.45	0.570	-103.0	-13.4	1070	1298	6.74	5
LL-S2 LITTLE LAKE	355610	1175402	950506	15.6	655.00	430.41	-9999	8.20	62.00	67.00	285.00	24.00	133.0	193.0	740.0	59.0	22.9	5.80	0.490	-109.0	-10.5	1220	1569	4.04	5
LL-S1 LITTLE LAKE	355508	1175400	951007	18.7	444.26	343.65	1700	8.26	39.10	59.80	271.00	28.60	204.0	114.0	542.0	18.4	32.0	6.37	0.520	-94.0	-11.1	1113	1283	6.46	5
LL-S1 LITTLE LAKE	355508	1175400	950506	15.2	614.00	365.54	-9999	8.70	36.00	67.00	297.00	25.00	201.0	140.0	601.0	51.0	34.1	5.90	0.510	-94.0	-9.9	1190	1424	6.08	5
LL-P1 LITTLE LAKE Pond	355615	1175355	951017	21.4	513.11	408.48	1720	7.85	79.60	51.00	230.00	24.90	182.0	105.0	626.0	44.8	32.6	5.58	0.480	-92.0	-11.3	1120	1349	3.30	5
LL-P1 LITTLE LAKE	355615	1175355	950506	19.5	633.00	434.17	-9999	7.40	80.00	57.00	250.00	22.00	110.0	183.0	772.0	67.0	21.2	5.20	0.400	-107.0	-12.7	1160	1546	1.31	5
LL-L2 LITTLE LAKE Lake	355630	1175350	951007	17.6	122.95	70.63	2260	10.18	5.71	13.70	432.00	34.40	269.0	352.0	150.0	5.6	35.8	7.52	0.850	-33.0	0.2	1440	1270	9.47	5
LL-L2 LITTLE LAKE	355630	1175350	950520	21.4	565.00	337.21	-9999	9.20	13.10	74.00	317.00	30.00	178.0	220.0	689.0	22.0	33.8	5.27	0.490	-65.0	-5.3	1200	1548	0.80	5
LL-L1 LITTLE LAKE	355706	1175340	960413	15.0	646.77	366.10	1980	8.85	26.00	73.20	331.00	28.80	189.0	219.0	633.0	38.7	47.8	3.95	0.548	-58.0	-5.0	1220	1543	4.99	5
LL-L1 LITTLE LAKE	355706	1175340	951007	19.9	184.43	134.45	2090	9.71	8.53	27.50	385.00	33.00	247.0	295.0	225.0	12.8	35.3	6.99	0.790	-45.0	-2.2	1360	1241	9.22	5
LL-L1 LITTLE LAKE	355706	1175340	950520	23.6	567.00	347.69	-9999	9.00	17.30	74.00	308.00	29.00	176.0	216.0	692.0	25.0	33.8	5.20	0.480	-66.0	-5.6	1200	1543	0.53	5
LL-L1 LITTLE LAKE	355706	1175340	940901	22.3	530.00	84.00	3100	11.00	7.00	16.00	590.00	57.00	370.0	480.0	480.0	4.0	52.9	7.00		-23.0	-4.3	1900	2011	0.57	5
LL STREAM, S. CULVERT, ROSE VALLEY	355530	1175500	970514	22.2	916.00	342.84	2030	8.82	39.60	59.30	263.70	21.30	205.2	141.1	623.2	46.8	35.1	5.85	0.430			1010	1406	-0.24	5
LL S. DOCK, LITTLE LAKE	355644	1175400	980517	18.0	218.00	233.35	1470	9.98	6.29	52.89	277.42	21.73	205.7	13.1	1108.9	0.0		0.46	1.090			750	1686	3.81	5
LL RANCH HOUSE WELL, ROSE VALLEY	355729	1175417	970602	21.1	312.00	280.95	1330	7.58	63.14	29.99	147.80	16.96	151.9	96.8	377.6	54.5	41.6	3.66	0.330	-105.0		660	942	-0.27	5
LL N. DOCK, LITTLE LAKE	355716	1175400	980207	8.0	396.00	300.08	1800	8.35	30.99	54.13	290.55	25.31	233.2	19.7	1388.2	0.0	55.8	4.18	1.050			900	2046	6.34	5
LL FAULT SPRING, ROSE VALLEY	355546	1175450	970214	20.4	143.00	263.14	1110	7.90	73.80	19.20	159.30	6.60	38.2	382.9	194.9	26.4	100.5	0.38	0.140			550	902	-0.08	5
LL EFF. STRM (6838), LITTLE LAKE	355630	1175400	940901	19.4	500.00	390.00	1900	8.40	49.00	64.00	260.00	19.00	230.0	150.0	600.0	72.0	50.0	4.60		-96.0	-10.8	1200	1449	-0.11	5
LL CANYON SPRING, SIERRA NEVADA	355704	1175610	970531	25.5	251.00	305.42	810	7.99	88.12	20.79	48.64	5.57	31.7	81.7	343.3	27.5	194.5	0.16	0.120			400	648	-0.07	5
LL CANYON 2	355645	1175620	950506	17.5	294.00	295.13	-9999	8.30	82.00	22.00	56.00	6.90	30.6	83.0	359.0	28.0	161.1	0.19	0.130	-101.0	-13.0	520	668	-0.58	5
LL CANYON 1	355700	1175610	950328	-9999.0	246.00	251.61	-9999	8.80	70.00	18.70	46.00	6.50	25.3	79.0	291.0	26.0	148.8	0.17	0.080	-95.0	-12.0	435	563	-0.32	5
LITTLE LAKE SPRING	355527	1175436	940227	17.1	431.15	327.70	1169	7.58	71.80	36.10	128.00	13.00	80.5	90.1	526.0	57.1				-103.0	-13.5	683	1003	-1.25	9
Northern LL Ranch Well									90.58	33.64	15.97	0.43	46.5	71.9	315.0	55.0	24.0	1.94					631		
Little Lake N-new			71213										74.0				43.5	1.70		-101.6	-13.8	650			Coso 07
Little Lake E Spring-new			71213										180.0				32.1	5.60		-100.5	-13.3	1110			Coso 07
Little Lake Spring, upper			86																	-97.0	-12.4				Bowman, UURI
Little Lake surface, lower			86																	-95.0	-11.1				Bowman, UURI
Little Lake surface, middle			86																	-94.0	-10.8				Bowman, UURI
COSO SPRING, LL RANCH, ROSE VALLEY	355615	1175250	970514	21.1	953.00	411.11	1250	7.31	82.70	49.76	213.30	17.90	180.6	106.1	653.2	60.8	34.9	5.18	0.380			931	1370	-0.25	5
B01, LITTLE LAKE	355637	1175417	930311	17.0	615.00	414.00	1900	8.30	59.00	65.00	282.00	26.00	193.0	163.0	750.0	29.0	35.1	5.50		-90.0	-10.1	1240	1573	0.10	12
LIEN WELL, SAGEFLAT RD.	361038	1175855	980502	17.0	280.00	315.56	870	7.72	92.25	20.75	62.41	3.55	134.6	11.6	317.0	2.0	1121.7	0.12	0.370			430	644	-0.67	5
KENNEDY MEADOWS, D5	360422	1180344	930413	8.0	42.00	28.00	102	6.98	8.00	2.00	12.00	2.00	9.0	4.0	51.0	22.0	11.3	0.80		-107.0	-14.3	110	111	-1.59	12
JORDAN HOT SPRING	361339	1181808	770000	43.0	1213.11	430.83	-9999	6.15	110.00	38.00	970.00	92.00	880.0	250.0	1480.0	190.0	40.0	22.00	1.600	-100.0	-12.4	3080	4032	-1.04	1
HAIWEE SPRING, COSO RANGE	360702	1174520	930506	12.0	221.00	234.00	645	7.60	64.00	18.00	47.00	6.00	40.0	63.0	269.0	41.0	26.7	1.50		-100.0	-13.7	550	550	0.09	12
HAIWEE SPRING, COSO RANGE	360702	1174520	790400	17.0	140.16	135.83	-9999	7.20	33.00	13.00	31.00	4.40	15.0	47.0	171.0	51.0	75.0	0.20		-96.0	-13.5	366	366	-0.56	10
HAIWEE SPRING, COSO RANGE	360702	1174520	740000	20.0	140.16	157.72	-9999	7.84	36.00	16.50	28.50	5.90	18.0	66.0	171.0	52.6	60.0	0.30		-98.0	-13.2	395	395	-1.66	10
HAIWEE RIDGE SPRING	360811	1175620	980517	18.0	142.00	87.15	400	8.08	25.43	5.76	44.57	5.83	19.1	40.9	253.8	0.6	45.5	0.42	0.050			396	396	-2.63	5
HAIWEE RESERVOIR, SOUTH DAM, ROSE VALLEY	360827	1175700	970531	8.0	39.00	70.79	300	8.20	20.90	4.53	35.30	3.90	17.3	34.6	111.2	15.8	32.0	0.54	0.030			244	244	-0.30	5
HAIWEE RESERVOIR, ROSE VALLEY	361106	1175745	790400	14.0	124.59	68.86	-9999	7.60	21.00	4.00	35.00	3.60	17.0	17.0	152.0	26.0	37.8	0.45	0.030	-117.0	-14.3	276	276	-5.71	10
HAIWEE PUMP STATION STREAM, ROSE VALLEY	360612	1175715	970531	16.0	37.00	93.41	380	8.20	27.64	5.94	45.97	5.73	17.5	34.1	169.6	40.6	33.7	0.52	0.040			348	348	-0.20	5
HAIWEE CREEK	360815	1180148	980517	7.0	233.00	193.57	560	8.45	52.99	14.91	37.81	5.08	31.6	35.7	368.8	8.3	395.0	0.08	0.210			555	555	4.14	5
Haiwee Cyn	360818	1180173	790400					7.90	62.00	18.00	39.00	6.00	28.0	32.0	327.0	62.0	46.7	0.60		-109.0	-14.7	575	575		10
GRUMPY BEAR WELL IWV1	355920	1180556	860916	12.0	290.00	312.00	830	7.49	82.00	26.00	52.00	6.00	19.0	99.0	290.0	21.5	380.0	0.05				436	596	7.88	29

Geochemical Database for Rose Valley Hydrological Sysyem Based on Guler, 2002 with Additional Data

SITE NAME	LATITUDE	LONGITUDE	DATE	TEMP	ALK	HARDNESS	COND	pH	Ca	Mg	Na	K	Cl	SO4	HCO3	SiO2	Cl/B	B	Br	Deuterium ‰	Oxygen-18 ‰	TDS	TDS(sum)	BALANCE	DATA SOURCE
GRUMPY BEAR WELL IWV1	355920	1180556	790400	5.0	272.13	312.46	-9999	-9999.00	84.00	25.00	55.00	5.50	21.0	90.0	332.0	24.0	140.0	0.15		-106.0	-13.5	637	637	5.00	10
FIVE MILE CANYON SIDE STREAM	355304	1175658	960504	17.6	265.20	285.36	740	8.10	67.20	28.60	50.80	8.38	26.8	91.1	322.0	33.7	141.1	0.19	0.087	-99.0	-12.5	482	629	0.94	5
EDGAR'S SPRING	355540	1180032	960824	21.0	389.00	284.06	703	7.67	80.70	20.10	32.00	3.73	25.5	37.4	373.0	31.3	212.5	0.12	0.040	-109.0	-14.1	417	604	-3.11	25
DUNMOVIN WELL, ROSE VALLEY	360527	1175700	970531	30.0	229.00	307.21	1280	8.00	78.96	26.78	150.70	6.40	52.0	330.0	276.2	29.6	29.8	1.75	0.140			952	952	-0.14	5
DEWS WELL, LAKEVIEW DR.	360916	1175810	980516	17.0	144.00	227.80	610	7.42	59.70	19.16	31.64	2.90	77.3	11.5	290.0	4.3	286.3	0.27	0.200			497	497	-2.06	5
DEAD END SPRING, COSO RANGE	360739	1174137	790400	12.0	215.57	213.18	-9999	6.95	64.00	13.00	35.00	1.70	23.0	30.0	263.0	34.0	115.0	0.20		-96.0	-12.9	464	464	2.01	10
COSO JUNC. WEST WELL, ROSE VALLEY	360252	1175715	970521	22.2	179.00	208.40	680	7.71	60.98	13.67	52.46	5.33	40.5	71.9	233.8	24.7	663.9	0.06	0.170			503	503	-0.06	5
COSO JUNC. STORE WELL, ROSE VALLEY	360235	1175638	970521	24.4	303.00	363.88	970	7.39	89.60	34.10	54.50	9.10	45.6	119.2	369.5	61.7	138.2	0.33	0.190			784	784	-0.13	5
JUNC. US395 WELL	360237	1175646	740000	23.0	245.90	252.58	-9999	7.53	60.00	25.00	40.00	3.00	26.0	68.0	300.0	41.3	130.0	0.20		-102.0	-13.6	564	564	-1.53	10
Junction Store	F-04																			-100.5	-13.9				GeoTrans, 2004
Coso Junction #1-new	7-Dec												33.0				100.00	0.33		-101.5	-13.8	510			Coso, 2007
COLES SPRING, COSO RANGE	360900	1174008	790400	13.0	147.54	307.86	-9999	7.18	97.00	16.00	44.00	2.40	30.0	140.0	180.0	42.0	150.00	0.20		-98.0	-12.8	860	552	9.41	10
CHINA GARDEN SPRINGS, COSO RANGE	361203	1173623	790400	14.5	126.23	237.87	-9999	-9999.00	64.00	19.00	54.00	8.10	55.0	130.0	154.0	38.0	137.50	0.40		-92.0	-13.1	523	523	3.53	10
CHIMNEY PEAK SPRING	355301	1180328	790400	9.0	223.77	228.15	-9999	6.90	70.00	13.00	18.00	3.60	18.0	36.0	273.0	29.0	120.00	0.15		-102.0	-13.6	461	461	-2.71	10
BIG PINE SPRING	355650	1180451	790400	7.0	177.05	173.26	-9999	7.00	48.00	13.00	23.00	3.50	12.0	32.0	216.0	22.0	100.00	0.12		-104.0	-13.8	370	370	-0.04	10
ARTESIAN WELL, ROSE VALLEY	355603	1175417	970521	22.2	545.00	395.42	1830	6.77	77.50	49.10	217.30	18.60	181.3	104.6	647.0	59.1	35.55	5.10	0.350			922	1360	-0.25	5
21S/32E-31Q01 KENNEDY MEADOWS	360000	1180500	950402	-9999.0	52.05	40.04	-9999	8.00	11.10	3.00	16.70	4.00	13.1	3.7	63.5	8.9	21.13	0.62	0.025	-112.0	-14.7	110	125	4.30	5
21S/32E-31Q01 KENNEDY MEADOWS	360000	1180500	940601	-9999.0	147.54	124.36	-9999	8.00	35.00	9.00	41.00	5.00	40.0	16.0	180.0	15.0	28.57	1.40		-101.0	-10.7	240	342	-0.21	5

Sources
5-CSU Bakersfield, unpulished data, Guler, 2002
10-Fournier and Thompson, 1980
12-Houghton, 1994
25-Sotdick, 1997
29-Whelan et al.,1989
Coso, 2007, personal communication, 2007
GeoTrans, 2004 Report to Coso

C4.1 Introduction

The reader is advised that the following hydrologic impact monitoring program is based on and contains many references to the hydrology impact analyses contained in the Hay Ranch Water Extraction Project Draft Environmental Impact Report (EIR). The reader is urged to read section 3.2 Hydrology and Water Quality in the EIR prior to reading this hydrologic monitoring and mitigation plan (HMMP).

This monitoring plan has been prepared in order to define monitoring of project activities to prevent potential off-site impacts of the proposed project on groundwater and surface water users in the Rose Valley. This plan also describes the methods to prevent a significant effect to ground and surface water users.

The first section of this plan includes the summary of hydrologic impacts and mitigation, as described in detail in the EIR. The second section of this plan describes the HMMP implementation methods.

This HMMP is designed to:

- Define methods for monitoring changes in groundwater levels throughout the Rose Valley;
- Compare observed changes to predicted changes and adjust model predictions as needed during the early operation of the project before any impact is predicted at Little Lake under the current model assumptions;
- Collect groundwater and surface water level data at Little Lake during the same early stages to develop time-trend water level data on Little Lake and to correlate the groundwater levels to Lake levels;
- Monitor later-stage groundwater and lake level changes as groundwater pumping continues;
- Recalibrate the numerical model developed for the project using data collected during the early stages to check and improve the model's ability to simulate stressed (pumping) conditions and to make predictions of future changes in groundwater levels and lake levels in response to pumping; and
- Facilitate the implementation of the mitigation measures defined in the EIR to avoid or reduce impacts to groundwater levels and lake levels before the impacts become significant.

Groundwater elevations and lake water levels are also influenced by natural factors beyond the effect of this project. These factors include rainfall in Rose Valley, snowfall in the Sierra Nevada Mountains, and seismic events that change the geomorphology of surface hydrological features or subsurface permeability. This monitoring and mitigation plan is not designed to mitigate naturally occurring changes in the hydrological system.

C4.2 Summary of Hydrologic Issues

C4.2.1 OVERVIEW

The Coso Operating Company, LLC (COC) is seeking a 30-year Conditional Use Permit (CUP No. 2007-003) from the Inyo County Planning Commission for the Coso Hay Ranch Water Extraction and Delivery System project.

The proposed project includes extracting groundwater from two existing wells on the Coso Hay Ranch, LLC property (Hay Ranch) in Rose Valley and delivering the water to the injection well distribution system at the Coso Geothermal Field in the northwest area of the China Lake Naval Air Weapons Station (CLNAWS). The proposed project is needed to provide supplemental injection water to the Coso Geothermal Field to minimize the annual decline in reservoir productivity due to evaporation of geothermal fluids from plant cooling towers. The project location is shown in Figure C4-1.

The Inyo County Planning Department (County) has prepared a Draft EIR pursuant to the California Environmental Quality Act (CEQA) to aid in the decision whether or not to issue the CUP. The Draft EIR assesses the potential impacts of the project on the environment.

Evaluation of the hydrological system within Rose Valley suggests that the project as proposed, which includes groundwater pumping at a rate of 4,839 acre-ft/yr for 30 years, may lower the water table elevation and groundwater flow rates in the valley (see Section 3.2 Hydrology and Water Quality of the EIR). If groundwater levels fall significantly in the southern end of the valley, the groundwater flow and surface water levels in the perennial but manipulated Little Lake may be affected, as well as several local wells. The magnitude of change in groundwater level and flow will vary depending on:

- Distance from the pumped well at Hay Ranch
- Magnitude and duration of pumping
- Manipulations at the Little Lake weir

Predictions of the effects of groundwater extraction associated with the project also depend on various assumptions of aquifer properties, boundary conditions, and aquifer recharge.

C4.2.2 PUMPING TEST AND COMPUTER MODELING RESULTS

Many sources of information on local and regional hydrology and geohydrology were used to evaluate aquifer properties and identify groundwater conditions during preparation of the EIR. Consultants for the Coso Operating Company (COC) previously performed short term (24 hour) groundwater pumping tests and conducted computerized hydrologic modeling for the proposed project. These studies have been reviewed and used as appropriate to describe the environmental setting and to analyze the project impacts. During preparation of the project EIR, COC conducted a long-term (14 day) pumping test. Consultants to Inyo County subsequently used the data from the long-term pumping test to evaluate aquifer properties and to recalibrate and refine the computerized hydrologic model developed for COC. The 14-day groundwater pumping test was conducted in the Hay Ranch south well.

Groundwater levels were monitored throughout Rose Valley for a 20-day period before, during, and after the pumping test. In addition, groundwater discharge from the Davis spring at Portuguese Bench was measured during the pumping test. The well pumping lowered groundwater levels up to 0.4 ft in wells at Coso Junction, approximately two miles south of the pumped well, but, not surprisingly given the limited duration of the pumping, it had no discernable effect on groundwater levels in wells on Navy property 5 to 7 miles south of the pumped well, or in a well located at the north end of the Little Lake Ranch property, 8 miles south of the pumped well. Minor changes observed in the groundwater discharge rate from the Davis spring at Portuguese Bench during the test did not appear to be correlated with the pumping test. The pumping test is described in Appendix C1 of the Draft EIR.

Figure C4-1: Project Location

SOURCE: ESRI 2006, Coso Operating Company 2007, and MHA Environmental Consulting 2007

The groundwater drawdown data obtained during the pumping test from the Hay Ranch north well and other wells close to Hay Ranch, as well as hydrogeologic information from several sources, were used to recalibrate a computerized groundwater flow model previously developed to evaluate groundwater conditions in Rose Valley (Brown and Caldwell, 2006). The recalibrated groundwater flow model consists of four layers, including one unconfined (water table) layer, and three confined layers. The model was used to analyze potential long-term effects of the proposed groundwater pumping at Hay Ranch.

The results of the groundwater flow modeling indicated that the principal impact in Rose Valley from operation and maintenance of the Hay Ranch groundwater extraction project will be the propagation of groundwater table drawdown off the property as a result of removing groundwater on the Hay Ranch property and transporting it outside the Rose Valley groundwater basin (to the Coso geothermal field). Numerical groundwater flow modeling analysis was conducted to evaluate potential impacts of project operation on groundwater levels in the Rose Valley. The model setup, calibration, and prediction simulations are described in Appendix C2 of the EIR.

The groundwater flow modeling predicts that groundwater table drawdown will increase with time after pumping begins at Hay Ranch. The modeling predicted that less drawdown will be observed farther away from the pumped wells, as expected based on groundwater flow theory. After pumping is stopped, groundwater levels near Hay Ranch will soon begin to rise back to pre-project levels; however, depending on the magnitude and duration of pumping at Hay Ranch, groundwater levels at the south end of the valley may continue to decline in elevation even after pumping at Hay Ranch has stopped before they also begin to rise back to pre-project levels.

Proposed pumping at a rate of 4,839 acre-ft/yr for 30 years is predicted to cause a maximum groundwater table drawdown of:

- 25 to 55 ft in wells in the Dunmovin community and LADWP wells located 1.5 miles north of Hay Ranch
- 20 to 50 ft in wells at Coso Junction 2 miles south of Hay Ranch
- 5 to 20 ft near the Cinder Road Red Hill well 6.5 miles south of Hay Ranch
- 3 to 11 ft at the north end of Little Lake at the south end of the valley, 9 miles south of Hay Ranch

The range in predicted drawdown impacts listed above reflects uncertainty in assumed values for aquifer specific yield. Low specific yield values result in greater and earlier the drawdown, while higher specific yield values result in less drawdown with time and less drawdown farther from the pumped wells. Published values of specific yield (Johnson 1967, Morris and Johnson 1967) range from 2 % for clay to 35 % for well-graded gravels, in unconfined (water table) conditions. Groundwater-yielding sediments encountered in Rose Valley consist primarily of sand and gravel interbedded with clays; most of the groundwater would come from the more readily drainable sand and gravel horizons. Because specific yield could not be determined from the pumping test data, a range of values corresponding to high, medium, and low values of 30, 20 and 10% were used in the project development impact analyses. The model results were particularly sensitive to the value used for specific yield, because that value is a measure of the change in water level in the aquifer per unit of groundwater that is pumped.

Groundwater modeling also indicates that the amount of drawdown is directly related to the amount of withdrawal. For example, assuming 20% specific yield and pumping for 30 years, predicted drawdown at the north end of the Little Lake ranges from approximately 1.2 ft at an extraction rate of 1,500 acre-ft/yr to approximately 3.2 ft at an extraction rate of 4,000 acre-ft/yr. The predicted change in drawdown is roughly linearly proportional to the project pumping rate; that is, pumping at 3,000 acre-ft/yr has roughly twice the impact of pumping at 1,500 acre-ft/yr.

Several springs located in upland portions of Rose Valley including the Davis Spring at Portuguese Bench, and the Tunawee Canyon Spring in Tunawee Canyon, and the Rose Spring near Haiwee Reservoir. They are sustained by mountain-front recharge in the Sierra Nevada Mountains or seepage from Haiwee Reservoir or Owens Valley. These springs are located at significantly higher elevations and are unlikely to be impacted by the project; therefore, they will not be monitored during project operation.

C4.2.3 DEFINITION OF SIGNIFICANT IMPACTS TO LITTLE LAKE AND SURFACE WATERS

The EIR identifies that the project would have a significant impact if it would substantially reduce the amount of water available to surface water bodies at Little Lake Ranch and to other areas in the Rose Valley. A substantial reduction in the amount of water available at Little Lake is defined as greater than 10% reduction in water flowing into the surface features at Little Lake.

Defining thresholds of significant effects to the environment by attempting to measure or predict those effects on vegetation around Little Lake Ranch was considered and rejected. The Little Lake area is highly manipulated. Little Lake is a reservoir, whose level is manually controlled. The vegetation surrounding the area south of Little Lake is manipulated by removal of undesirable species, planting of others, and by moving water to various areas where managers intend to promote vegetation. As a result, there is no natural background condition against which to measure effects. Additionally, by moving water around the property, vegetation may be encouraged in areas not currently highly vegetated and discouraged in areas now heavily vegetated if management objectives for the restoration project shift. Therefore, by necessity, it is most appropriate to emphasize measuring impacts to the amount of water that is available to the restoration project, rather than biological indicators.

C4.2.4 MITIGATION MEASURES DEFINED IN THE EIR

Summary of Impacts and Mitigation

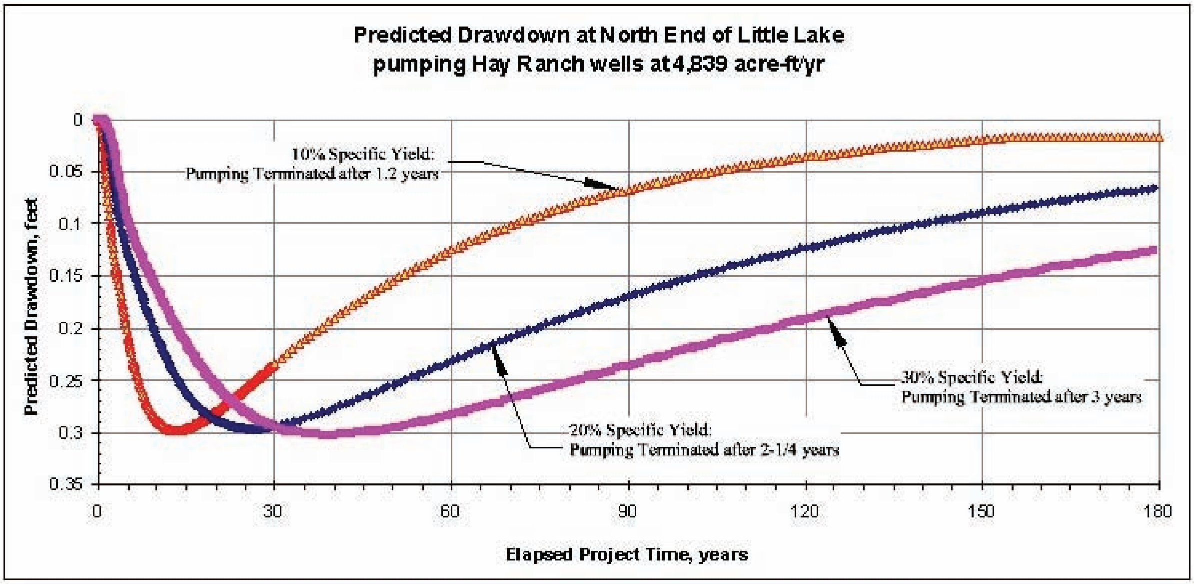
The existing groundwater model predicts that, with a specific yield value of 10%, the project as proposed (pumping at a rate of 4,839 ac-ft per year for 30 years) would have a significant impact on Little Lake (refer to Section 3.2 Hydrology and Water Quality in the EIR).

In order to prevent a significant impact to Little Lake and surrounding surface waters, water inflow to the lake must not decrease by more than 10% of the baseline flow. Data from Bauer (2002) indicates that the historical groundwater elevation at the north end of Little Lake was consistently 3 feet higher than the lake level; because groundwater flow is proportional to the hydraulic head gradient, a 0.3 foot decrease in the groundwater represent a 10% decrease in gradient, and is estimated to correlate to a 10% reduction in discharge of groundwater to Little Lake.

A maximum of 10% reduction in groundwater inflow to Little Lake (this is currently benchmarked to a drawdown of 0.3 feet in the Little Lake North Dock well) would occur following pumping at Hay Ranch at proposed pumping rates for a period of approximately 1.2 years (see Figure C4-2). The model predicts that this maximum drawdown would occur as much as 30 years after the cessation of pumping at 1.2 years, due to the large distance (9 miles) from the pumping.

Mitigation, therefore, allows initiation of pumping for the project at the proposed project pumping rate, until drawdown trigger levels are reached at one or more monitoring locations throughout the valley (Table C4-1). Model predictions indicate that the trigger levels could be reached with pumping occurring in as little as 1.2 years; however, some conservative assumptions that are built into the model may extend this pumping period considerably longer, if actual decreases in the groundwater level occur more slowly than predicted. The trigger points have been established

Figure C4-2: Early Pumping Termination (1.2 years) Scenario Results



using the model to prevent a greater than 10% decrease in flows to Little Lake from ever occurring. Monitoring should occur monthly for at least two years, with results reported to the County within 2 weeks of data collection. After two years, if water levels are decreasing more slowly than predicted, the applicant can petition the County to reduce the measurement frequency to quarterly.

Data collection in the first few months to years would lead to a better understanding of the relationship between pumping at Hay Ranch and groundwater table drawdown throughout Rose Valley and at Little Lake. Data to be collected includes: water level data over time to establish background levels; response of water levels to pumping that will be used to evaluate specific yield and hydraulic conductivity; lake level data; groundwater level data adjacent to Little Lake; and other data needed to re-calibrate the groundwater flow model. These and other data that will be collected are specified in Subsection C4.3.3 and Table C4-2. Pumping may continue as long as the project does not result in a significant decrease in groundwater available at Little Lake at any point in time.

Within approximately 1 year of initiation of pumping, or less if trigger levels are reached sooner, the groundwater flow model should be recalibrated to the observed drawdown in groundwater levels, to allow for more accurate estimation of how long the pumping can continue without exceeding drawdown trigger levels and causing a significant reduction in water available to Little Lake, the springs, and wetlands. A qualified person approved by Inyo County Water Department, and provided by the applicant, would evaluate the results of the first year of data collection, would recalibrate the model, and working with the Inyo County Water Department and the applicant would estimate the duration of pumping that would keep impacts below the defined trigger levels. Recalibration of the model would also be necessary later, if pumping continues significantly longer than 1.2 years, as needed and appropriate to help understand the timing and magnitude of future drawdown of groundwater levels throughout the valley. A maximum limit of 10% groundwater inflow reduction to Little Lake has been selected, to avoid a significant effect on Little Lake. The computer groundwater flow model was used to define equivalent maximum acceptable drawdown levels, (maximum water level drawdown values) at various points up the valley that cannot be exceeded at any point in time. Water level drawdowns that were maintained below those maximum acceptable drawdown levels would, based on model results, avoid a depletion of groundwater inflow to Little Lake of more than 10%. The model was used to identify corresponding "trigger levels, water level drawdowns at earlier points in time, that would eventually lead (under continued pumping) to reaching the maximum acceptable drawdown levels, at each monitoring point. Requiring that observed drawdown values over time be kept below these defined trigger levels would provide an early warning system, allowing for the system operations to change, to reduce or stop pumping before maximum acceptable drawdown levels propagated down the valley to Little Lake.

Exceedance of predicted groundwater drawdowns (**trigger levels**) at two or more locations in Rose Valley, or exceedance of a **maximum acceptable drawdown level** at any location, would be a cause for action as determined by the County, including re-calibration of the model and potential reductions or cessation of pumping. See Table C4-1 for trigger levels and maximum acceptable drawdown levels.

Table C4-1: Drawdown Trigger Levels (in feet)

Project Elapsed Time, years	Dunmovin Area well	Pumice Mine well	Hay Ranch Observation well	Coso Ranch North well	Coso Junction #1 well	Navy G-36 well	Navy Lego well	Red Hill Cinder Road well	Navy 18-28 well	Little Lake Ranch North well
	Distance from Hay Ranch South Well (feet)									
	9,000	***6,100***	***1,300***	***9,700***	***10,900***	***26,000***	***27,300***	***32,000***	***38,000***	***42,600***
0.25	<0.2	0.5	3.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
0.5	0.3	1.3	4.7	0.4	0.3	<0.2	<0.2	<0.2	<0.2	<0.2
0.75	0.7	3.3	8.1	0.9	0.7	<0.2	<0.2	0.2	<0.2	<0.2
1	1.1	5.3	11.5	1.4	1.2	<0.2	<0.2	0.2	<0.2	<0.2
1.2	1.5	6.9	13.2	1.8	1.5	0.2	0.2	0.3	<0.2	<0.2
1.25	1.6	7.1	11.8	1.9	1.6	0.2	0.2	0.3	<0.2	<0.2
1.5	1.9	7	7.9	2.1	1.8	0.2	0.2	0.3	<0.2	<0.2
1.75	2.1	6.5	6.9	2.3	2	0.3	0.3	0.3	<0.2	<0.2
2	2.3	6	6.2	2.4	2.1	0.3	0.3	0.4	<0.2	<0.2
3	2.7	4.8	4.8	2.5	2.2	0.5	0.4	0.4	<0.2	0.2
4	2.8	4.1	4	2.5	2.2	0.6	0.6	0.5	0.2	0.3
5	2.7	3.6	3.5	2.4	2.2	0.7	0.7	0.6	0.3	0.3
Maximum Acceptable Drawdown (in feet)	2.8	7.2	13	2.5	2.3	1.1	1.1	0.7	1	0.4
Time to Max drawdown (years since pumping began)	4	1.3	1.2	3	3.5	14.5	15	12	22	13

NOTES

1) For any wells where predicted drawdown is less than or equal to 0.25 feet, actions related to these trigger points shall not be enforced, unless the drawdown seen in these wells is greater than 0.25 feet. Drawdown values of <0.25 feet are difficult to accurately detect.

2) Based on current groundwater flow model results, these maximum drawdown values listed above result from pumping the Hay Ranch production wells at design rates for 1.2 years, with specific yield values of 10%. These maximum acceptable drawdowns can occur several years after pumping at Hay Ranch ceases.

Mitigation Measures from EIR

The following mitigation measures have been defined in the EIR to reduce potentially significant impacts to water users in the Rose Valley. Note that references to Appendix C4 are included in the measures since these measures are taken directly from the EIR. This HMMP is Appendix C4 of the EIR and references are included in the sections of this document.

> **Hydrology-1:** The project applicant shall finalize and implement the Draft Hydrological Monitoring and Mitigation Program (HMMP) included in Appendix C4 [this appendix] of this EIR.
>
> **Hydrology-2:** Mitigation for effects to groundwater wells in Rose Valley shall depend upon the specific characteristics of each well, and the use of the well. The applicant shall use monitoring data and the numerical groundwater flow model described in Appendix C2 to track groundwater levels throughout the valley. The applicant shall work with the County Water Department to identify wells that may be affected by groundwater drawdown as the project progresses. The evaluation of wells depths and uses in the Rose Valley as compared with groundwater drawdown shall be made semi-annually and reported to the Inyo County Water Department. The owner of any wells that may potentially be impacted within the six months after an evaluation shall be contacted by the applicant to assess the need for additional pumping equipment on the well or deepening of the well. The applicant shall be responsible for the cost of equipping or deepening wells that are impacted by groundwater drawdown as a result of the proposed project. The applicant shall also evaluate any wells that are brought to the attention of the applicant by the user to evaluate if groundwater drawdown from the proposed project is impacting the well. If it is determined by the County or by the applicant (using well monitoring data and modeling) that the well in question is being impacted by the proposed project, the applicant shall fund the necessary adjustments to the well to secure the previous uses of the well. Disputes as to the cause of well water drawdown or appropriate corrective measures shall be resolved by the County.
>
> **Hydrology-3:** Monitoring shall occur at a frequency that is sufficient to detect important changes and trends in water levels. Monitoring shall occur monthly, at a minimum, at all monitoring points, following project start-up. The data shall be collected and analyzed by a qualified person approved by Inyo County Water Department and provided by the applicant. Monitoring reports shall be prepared by the applicant and submitted to Inyo County Water Department within 20 days of data collection. After two years, monitoring shall occur quarterly. Reports shall also be provided to a designated recipient at Little Lake Ranch, Inc. A complete list of monitoring locations, parameters, and schedules is presented in Appendix C4 [this appendix], Tables C4-1 and C4-2. Hydrologic monitoring locations are shown on Figure C4-2, in Appendix C4 [this appendix]. Two new monitoring well clusters, each with three wells with screened intervals at three different depths, located approximately 700 feet south of the Hay Ranch North Wells, and 700 feet south of the South Well, respectively, shall be installed by the project applicant, and as approved by the Inyo County Water Department. An additional new water table monitoring well shall be installed by the applicant and as approved by Inyo County Water Department, approximately midway between Coso Junction and the Cinder Road Red Hill well, to provide additional monitoring capability in this area.
>
> The monitoring program also includes reassessment of model-predicted impacts and recalibration of the groundwater model by a qualified person approved by the Inyo Count Water Department, and provided by the applicant. After a period of one year of pumping, observed groundwater level changes shall be compared with predicted groundwater-level changes in order to assess the accuracy of the model-predicted drawdown. If the observed water level changes at two or more of the selected monitoring points differ from predicted values (trigger levels) at those locations by at least 0.25 feet at any point in time, or a maximum acceptable drawdown is reached at a designated monitoring point, or as judged appropriate by Inyo County Water Department, the model shall be recalibrated and the predicted impacts to groundwater levels re-forecast with the recalibrated model. If the model results change with recalibration, the mitigation strategy shall be updated in response to

new forecasts of potential impacts to groundwater, potentially including reducing the duration or rate of pumping, or other mitigation measures as described in the HMMP. Additional recalibration is expected to be needed after one year, as monitoring continues and water level changes are detected farther down Rose Valley. Additional recalibration of the model shall be conducted as appropriate following the criteria outlined above (i.e. if the predicted water level in two or more wells differs from observed water level drawdown by at least 0.25 feet or more, or one or more maximum acceptable drawdown levels in wells all across the valley are exceeded).

Because surface water bodies at the Little Lake Ranch property are likely sensitive to changes in groundwater elevation and groundwater flow rate, the monitoring plan also identifies trigger levels that indicate when a significant impact (defined as a substantial reduction in water to Little Lake) will likely occur unless mitigation measures are implemented to reduce the pumping rate and/or duration of pumping. The plan includes the implementation of mitigation measures (namely, Hydrology-2 and Hydrology-4) to reduce any potentially significant impacts to less than significant levels.

Hydrology-4: The applicant shall be allowed to pump the project at the full proposed pumping rate until a time when and if the predicted groundwater drawdown trigger levels are exceeded at two or more of the designated Rose Valley monitoring points by at least 0.25 feet, or if a maximum acceptable drawdown level is exceeded in any monitoring point.

During the first year, a qualified person, approved by Inyo County Water Department and provided by the applicant, shall conduct the studies described in Hydrology-1 and Appendix C4 of this EIR in order to recalibrate the groundwater model to the early groundwater data. The groundwater model shall be recalibrated in order to more accurately understand the relationship between groundwater pumping, reduction in groundwater elevations across the valley, and availability of water at Little Lake. Pumping rates and duration of pumping shall be determined based on the results of the model and the observed water table drawdown. At no time shall projected results of pumping result in a greater than 10% decrease in groundwater inflow to Little Lake (estimated to be equivalent to a 0.3-foot drawdown in groundwater head at the northern end of Little Lake) unless new data collected in the vicinity of Little Lake indicates that a larger decrease of head would not result in a greater than 10% decrease in groundwater inflow to Little Lake or substantially deplete the water availability to the springs and wetlands (as defined in the Hydrologic Mitigation Monitoring Plan in Appendix C4 of this EIR [this appendix]).

The revised pumping rate and duration shall be approved by the Inyo County Water Department. The recalibration shall occur within one year after project startup to ensure adequate time is available to make adjustments to the pumping schedule if necessary, to ensure significant impacts do not occur. The model shall be calibrated to the new drawdown data collected since project startup. Based on the results of the recalibrated model, a revised schedule for pumping and revised trigger levels shall be determined that will not be expected to cause a greater than 10% decrease in groundwater inflow to Little Lake. A revised plan for pumping rate and/or duration of pumping shall be submitted with full documentation to the Inyo County Water Department by the end of the first year of pumping. Pumping can continue as long as trigger levels in designated monitoring points that prevent a significant impact are not exceeded, and other signs of substantial impact on surface water bodies (Little Lake, springs, and wetlands) are not observed, as determined by a qualified person approved by Inyo County Water Department provided by the applicant.

An alternative option to minimize impacts to Little Lake could include pumping for one or more years at full scale and model recalibration as prescribed above; however, then reducing pumping to a lesser degree and/or allowing pumping for a longer period of time along with implementing a groundwater diversion plan at Little Lake. The diversion system would include additional pumping from an existing well at the Little Lake Ranch property, if feasible, or construction of a new well. Water would be piped from the well location along existing unpaved roads to the lake where it would be discharged. Water would be withdrawn at the minimum rate necessary to sustain water availability to Little Lake and the lower pond areas. The pumping amount and duration for a water diversion at Little Lake would be determined by a qualified person approved by the Inyo Count Water Department, and provided by the applicant, based on the recalibrated model. The diversion plan is further described in Appendix C4 [this appendix]. Diversion would only be effective and implementable to minimize effects to less than significant levels if it were:

- Feasible given the availability of water at Little Lake and would not result in impacts to existing springs (e.g. Coso Spring)
- Agreed upon with Little Lake Ranch and the applicant
- Funded by the applicant
- Required for a reasonable timeframe (i.e., 20 years) that ensured accountability and funding by the applicant to mitigate all effects

If any of the above criteria are not met, then pumping would be scaled back or terminated based on model recalibration as previously described. If determined feasible, the applicant shall use biological and archaeological monitors during all ground disturbance activities associated with the construction of the augmentation plan components. The applicant shall also be responsible for obtaining any required permits for the diversion plan at the time that it is designed and implemented.

C4.2.5 GOALS AND OBJECTIVES OF THIS HMMP

A number of goals and objectives provide the framework for the HMMP, and form the basis for any future decisions regarding the HMMP needed to reflect an evolving understanding of the hydrologic and biologic systems in the Rose Valley and at Little Lake. The HMMP is designed to:

- Establish an understanding of baseline conditions in the hydrologic systems at Little Lake.
- Identify a system for predicting and mitigating for groundwater drawdown in existing wells in the Rose Valley.
- Identify potentially significant impacts to the hydrology at Little Lake as early as possible, by establishing “early-warning” trigger points, based on observed drawdowns in selected monitoring points and other hydrologic parameters. Early-warning trigger points would indicate potential impacts to wetlands and surface waters well in advance of actual, significant impacts.
- Redefine pumping rates and duration of pumping for the long-term project during the period of no effects to Little Lake through recalibration of the groundwater model based on data collected during the early phases of project development.

C4.3 HMMP Implementation

C4.3.1 HMMP IMPLEMENTATION RESPONSIBILITIES AND SCHEDULE

The monitoring and mitigation described in this HMMP will be performed by COC. COC will report results to the Inyo County Water Department on a monthly basis, and within 20 days of data collection. In addition, COC will submit quarterly and annual reports to the Inyo County Water Department summarizing the changes observed during the year and cumulative changes of the entire monitoring period, including conclusions and recommendations evaluating those changes relative to natural conditions such as rainfall and snowfall, assessing the significance of any changes compared to threshold levels if any, documenting any additional hydrologic modeling or adjustments to model-predicted impacts, and documenting any mitigation measures taken with respect to private wells or changes in Hay Ranch extraction rates. Data will also be provided to a designated contact at Little Lake Ranch, LLC.

C4.3.2 INYO COUNTY CODE CHAPTER 18.77 PROTECTIONS

It should also be noted that COC is subject to all regulations as stated in the Inyo County Code, Chapter 18.77.045 and 18.77.055, which allows for the CUP to be challenged at any time if conditions of the permit are not being implemented or pumping is proven to be “causing unreasonable effect on the overall economy or environment of Inyo County.” The permit could be modified or revoked as a result. Conditions of the code also help to minimize the potential for potentially significant impacts associate with the project. The final decision on any modifications to the CUP shall be in compliance with the Inyo County Code.

The Planning Commission may *revoke* the CUP if it finds that the water transfer can not be conducted without having an unreasonable effect on the economy or environment of Inyo County, regardless of the implementation of this HMMP.

C4.3.3 MONITORING PHASES

Four distinct monitoring phases will be implemented:

Phase 1: Monitoring System Setup and Supplemental Data Collection

Phase 2: Startup Monitoring and Reporting

Phase 3: Model Recalibration and Redefinition of Pumping Rates and Durations; and,

Phase 4: Ongoing Monitoring, Mitigation, and Reporting

Monitoring system setup consists of several tasks that will be completed concurrent with construction of the project, including the following:

- Installation of two new monitoring well clusters on the Hay Ranch property;
- Installation of one new monitoring well between Coso Ranch and the Cinder Road Red Hill well; and
- Surveying proposed monitoring locations and elevations to establish the baseline conditions.

Startup monitoring comprises monitoring undertaken during the first 1.25 years of operation of the project. Model recalibration would occur within the first year and would be used to determine future pumping rates and duration to minimize impacts to Little Lake. Ongoing monitoring comprises monitoring conducted throughout the life of the project.

Phase 1: Monitoring System Setup and Supplemental Data Collection

Monitoring system setup comprises various tasks designed to:

- Establish monitoring facilities and benchmarks to establish prevailing conditions prior to generating impacts and to establish the monthly baseline levels from which to compare the trigger level drawdown values in Table C4-1;
- Prepare supplemental engineering plans to specify a point of contact and mitigation measures to mitigate impacts to private wells (which may include deepening wells, changing pumping equipment, or compensating well owners for increased electricity costs for pumping);
- Collect supplemental data to address data gaps identified during preparation of the EIR, necessary for recalibration of the groundwater model; and
- Conduct supplemental engineering studies to evaluate the feasibility of extracting groundwater on the Little Lake Ranch property to augment water levels in the lake, and preparation of engineering plans to implement water diversion, if pursued at a later date.

Task 1.1: Monitoring System Setup

Monitoring system setup will include the tasks listed below. Existing wells that will be used for monitoring are shown on Figure C4-3. Proposed wells are described in the text, below.

a. Completing two new monitoring well clusters on the Hay Ranch property. The northernmost new well cluster location will be completed approximately 600 to 800 feet south of Hay Ranch North well, between the two existing wells. The second well cluster will be located approximately 600 to 800 feet south of Hay Ranch South well. Each well cluster will consist of: one shallow well screened across the water table, with the screen extending from approximately 10 feet above the current water table to approximately 100 feet below the current water table (i.e., approximately 190 feet to 290 feet bgs); an intermediate depth well screened from approximately 350 to 400 feet below ground surface (bgs); and a deep well screened from approximately 500 to 550 feet bgs.

   The purpose of the well clusters will be to provide access points for measuring groundwater drawdown on the Hay Ranch property outside of the pumped wells, so that groundwater drawdown at various depths can be assessed and aquifer parameters such as specific yield, storativity, and hydraulic conductivity can be evaluated. Because of well losses, drawdown measurements in the pumped wells themselves do not provide reliable information regarding water table drawdown in the aquifer.

b. Installing one new monitoring well approximately midway between Coso Junction and the Cinder Road Red Hill well. The well should be installed to intersect the water table, with a screen located approximately 10 feet above and 50 feet below the current water table.

c. Establishing access agreements, if possible, to monitor the Red Hill well on Cinder Road, one or more wells in the Dunmovin community, and two or more wells on the west side of Haiwee Reservoir approximately 7 miles south of Olancha (tentatively identified as the McNalley, Toone, Dews, or Buckland wells).

d. Installing pressure transducers and electronic data loggers in the six newly constructed Hay Ranch monitoring wells and the Little Lake North Dock well, to measure groundwater level, and in Little Lake to measure lake level. If the currently unused Little Lake Hotel well is found to be pressurized (artesian) then a pressure gauge should be installed on the well head; otherwise a reference point for manual water level measurements should be established.

e. Installing and calibrating flow measurement weirs at the discharge from Little Lake and at the North Culvert location previously used by Bauer (2002) to measure combined discharge from Little Lake, Coso Spring, the Little Lake siphon well, and the two perennial ponds (P-1 and P-2) on the Little Lake Ranch property.

f. Surveying the locations and casing elevations of wells added to the monitoring network at Hay Ranch, Dunmovin, Enchanted Lake Village, Red Hill, Fossil Falls, Little Lake Hotel, and Little Lake North Dock wells and any other designated monitoring points in Rose Valley where elevations are uncertain. Also, to be surveyed are the locations and elevations of surface water features on the Little Lake Ranch property including a reference point for Little Lake water level; base and adjustment points for Little Lake weir; Coso Spring; the siphon well head and discharge point; ponds P-1 and P-2; and, the North Culvert weir.

g. Evaluating existing well pump depths at Dunmovin, Coso Junction and Red Hill wells. The owners will be contacted to assess current pump depth and performance.

h. Preparation of required and optional supplemental engineering plans primarily consists of two tasks:

   – (Required) Establishment of a private well mitigation plan that would include a single point of contact for each well for resolving issues with respect to possible project impacts on existing private wells in the valley; identifying suitable qualified contractors to address issues such as pump deepening or replacement, or well deepening; putting a process in place to pay for such work.

Figure C4-3: Existing Wells that will be used in Hydrologic Monitoring

SOURCE: Geologica 2008

LEGEND

- ▲ Spring or Siphon Well
- ● Pumping Well
- O Out-of-Use Well

Approximate Scale in miles

0 1 2

MHA ENVIRONMENTAL CONSULTING An RMT Business

– (Optional) Preparation of a groundwater diversion plan for Little Lake capable of providing water to augment water levels in the lake. As discussed in Section C4.1.4, this plan would only be prepared and implemented if Little Lake Ranch agreed to this diversion, adequate groundwater was documented to be available on the Little Lake property, the diversion could be conducted for a reasonable time frame (i.e. no more than 20 years), and the applicant agreed to fund the diversion. This would include an evaluation of existing wells at the Little Lake Ranch property to assess their potential yield, location relative to the lake, pump, piping and electrical needs, and lift requirements. The plan would then include tentative specifications for well construction, if needed, pump, piping, electrical work, controls, and flow meters as well as an assessment of permitting requirements and likely lead times for construction and permitting.

i. **Establish background groundwater levels**. Establishing a pre-pumping statistical background water level for each designated monitoring point is essential, in order to distinguish between natural seasonal variability versus drawdown caused by pumping associated with the project. Establishing a background for each monitoring point will require pre-pumping measurements to be conducted for a sufficient period of time to encompass normal seasonal variations in water level.

   A minimum of 6 months of water level data will be required to establish the background water level at each monitoring point, and it is recommended but not required that 12 months of data be collected. The applicant shall conduct statistical evaluation of the background water level data by a qualified person approved by Inyo County Water Department and provided by the applicant. An appropriate statistical method to calculate the background water levels shall be proposed by the applicant, subject to approval by Inyo County. Upon approval, the background water level for each monitoring point shall be calculated by the applicant and presented to Inyo County Water Department for review and approval. It is anticipated that statistical methods similar to those used to calculate background concentrations of naturally occurring chemical constituents at RCRA and CERCLA sites may be applicable.

Task 1.2: Supplemental Data Collection and Evaluation

Supplemental data evaluations comprise the following tasks:

a. Evaluate groundwater levels beneath Little Lake, by installing temporary mini-piezometers to a depth of approximately 3 feet or more beneath Little Lake, at a minimum of four locations (for mini-piezometer and potentiomanometer details, see Wantry, R. and T.C. Winter, 2000). A Simple Device for Measuring Differences in Hydraulic Head Between Surface Water and Shallow Ground Water. U.S. Geological Survey Fact Sheet FS-077-00. June 2000). Measure the water levels relative to lake level, to evaluate the magnitude of the hydraulic gradient into or out of the lake, at four or more locations situated around the lake to obtain a representative evaluation of the hydraulic gradient between Little Lake and the underlying groundwater, prior to startup of the wells at Hay Ranch. Conduct measurements at the same locations for a period of six months prior to startup of the pumping system, to establish the background condition beneath the lake.
b. Depth to bottom and location measured using a hand held GPS unit at approximately 20 locations across Little Lake will be used to develop a preliminary bathymetric survey map.
c. Groundwater samples will be collected at each of the selected monitoring locations in Rose Valley to establish background (pre-pumping) conditions prior to the onset of pumping. The relationship between specific conductivity measured with a hand-held field instrument and total dissolved solids measured in the laboratory (preferably using EPA method 160.1) will also be assessed, for on-going electrical conductivity field measurements to be taken on a quarterly basis (four times/year) at a minimum.
d. Compilation of data on rainfall in Rose Valley (see Coso Hot Spring Monitoring Program 2005-2006, Geologica, 2007) and snow fall in the Sierra Nevada Range for the last 20

years to establish mean values for each and historical trends prior to project startup. These data will be used to assess future changes or trends in the relative level of potential recharge for each monitoring year.

Phase 2: Startup Monitoring and Reporting

Monitoring

The objective of start-up monitoring is to document the response of the aquifer to pumping. Data collected during the start-up monitoring phase will be used to improve estimates of aquifer specific yield, storage coefficients, hydraulic conductivity, and groundwater recharge rates as well as to better understand hydrologic conditions at Little Lake. These monitoring data will be used to validate and/or revise the computerized hydrologic model-predicted impacts long before thresholds of significance are reached. Start-up monitoring will continue for up to two years and includes the locations and parameters identified in Table C4-1 and as defined in Table C4-2, below.

Table C4-2: Hydrologic Monitoring Parameter Summary Rose Valley Hydrologic Monitoring and Mitigation Program

Monitored Location (1)	Parameters Monitored	Monitoring Frequency	Threshold Requiring Action	Action if Threshold Exceeded
Groundwater Level, Extraction				
Hay Ranch North and Hay Ranch South wells	Total Groundwater Extracted	Daily	Pumpage not to exceed 4,839 acre-ft per year	Reduce or discontinue pumping.
Six New Hay Ranch Observation wells (2 nests of 3 wells)	Groundwater Elevation	Measured hourly at a minimum using dedicated pressure transducer with data downloaded and plotted weekly for the first 3 months, then monthly. Supplement with manual measurements weekly for the first three months, then monthly.	Deviation of observed drawdown in two or more wells is at least 0.25 feet more than predicted trigger level value at any time beyond 4 months.	Alert County. County evaluates whether reduced pumping is appropriate prior to model recalibration. If appropriate, recalibrate model within one month and reassess impact to Little Lake.
			Groundwater level decline in two or more wells exceeding updated model predicted drawdown trigger levels by more than 0.25 feet in any quarterly data collection and monitoring period	Alert County. County to determine if decreased pumping is necessary immediately. Increase monitoring frequency to weekly for one month to confirm observation. Include results as part of quarterly data submittal. Recalibrate model within one month.

Table C4-2 (*Continued*): Hydrologic Monitoring Parameter Summary Rose Valley Hydrologic Monitoring and Mitigation Program

Monitored Location (1)	Parameters Monitored	Monitoring Frequency	Threshold Requiring Action	Action if Threshold Exceeded
			Maximum acceptable drawdown level from Table C4-1 exceeded	Pumping ceases until the model is recalibrated and will re-start only if it can be shown that pumping can continue at a rate that will maintain wetlands and water levels at Little Lake Ranch.
Pumice Mine well	Groundwater Elevation	Monthly for first two years, then quarterly	Deviation of observed drawdown at least 0.25 feet from predicted trigger level value at any time beyond the first quarter in two or more wells	Alert County. Recalibrate model within one month. Reassess potential impact to Little Lake. County to evaluate whether reduction in pumping is warranted.
LADWP V816			Groundwater level decline exceeding updated model predicted drawdown trigger levels by more than 0.25 feet in any well in any quarterly data collection and monitoring period	Alert County. Increase monitoring frequency to weekly for one month to confirm observations. Include results as part of quarterly data submittal. Recalibrate model within one month. County to evaluate whether and when a reduction in pumping is warranted.
Dunmovin well				
Coso Junction #1, Coso Ranch North Well				
Lego well				
Well G-36				
Well 18-28				
Fossil Falls Campground well. New well to be located between Coso Jnc and Cinder Road Red Hill well				
Cinder Road, Red Hill well			Maximum acceptable drawdown level from Table C4-1 exceeded	Pumping ceases until the model is recalibrated and will re-start only if it can be shown that pumping can continue at a rate that will maintain wetlands and water levels at Little Lake Ranch.
Little Lake Ranch North well	Groundwater Elevation	Monthly for first two years, then quarterly	Deviation of observed drawdown at least 0.25 feet	Revise trigger level based on Little Lake hydrology study

Table C4-2 (*Continued*): Hydrologic Monitoring Parameter Summary Rose Valley Hydrologic Monitoring and Mitigation Program

Monitored Location (1)	Parameters Monitored	Monitoring Frequency	Threshold Requiring Action	Action if Threshold Exceeded
			more than predicted value at any time beyond the first quarter	Reduce or cease pumping at Hay Ranch at the direction of the County. Augment flow to Little Lake in accordance with EIR Section 3.2.3 (Hydrology-3) and implement the Augmentation Plan to maintain groundwater level above trigger level
			Groundwater level decline exceeding updated model predicted drawdown by more than 50% in the well in any quarterly data collection and monitoring period	Alert County. Increase monitoring frequency to weekly for one month to confirm observations. Include results as part of quarterly data submittal. Recalibrate model within one month. County to evaluate whether and when a reduction in pumping is warranted. .
			Maximum acceptable drawdown level from Table C4-1 exceeded	Pumping ceases until the model is recalibrated and will re-start only if it can be shown that pumping can continue at a rate that will maintain wetlands and water levels at Little Lake Ranch.
At least two of McNalley, Toone, Dews, or Buckland wells located west of Haiwee Reservoir	Groundwater Elevation	Monthly for first two years, then quarterly	N/A. Information used to update model	N/A
Haiwee Reservoir	Stage level	Request average weekly values from LADWP	N/A. Information used to update model	N/A
LADWP Aqueduct	Flow rate			
Little Lake Hydrology				
Little Lake Hotel Well and Little Lake North Dock well	Groundwater Elevation (or closed well pressure)	Measured hourly using dedicated pressure transducer	No threshold applied, Information used to update model and	N/A

Table C4-2 (*Continued*): Hydrologic Monitoring Parameter Summary Rose Valley Hydrologic Monitoring and Mitigation Program

Monitored Location (1)	Parameters Monitored	Monitoring Frequency	Threshold Requiring Action	Action if Threshold Exceeded
Little Lake	Lake Water Level Elevation	with data downloaded and plotted weekly for the first 2 months, then monthly.	trigger levels.	
Little Lake Weir	Little Lake Weir Discharge and Weir Height(1)			
Little Lake North Culvert Weir	Little Lake System Discharge Rate			
Groundwater beneath Little Lake (minimum of four locations)	Groundwater elevation relative to lake	Monthly for 6 months after startup; then Quarterly		
Little Lake Ranch Pond P1	Occurrence of Siphon Well Discharge	Weekly by visual inspection; discontinue at end of baseline monitoring period		
Little Lake	Major operational changes	Request quarterly reporting of any major operational changes to lake level or groundwater pumping on property.	1 ft or more change in lake level or groundwater pumping on property in excess of 100 gpm daily average	None applicable. Data to be used for model updates, if needed, and for evaluating basin wide groundwater level responses in quarterly data submittal
Groundwater Quality				
Hay Ranch North and Hay Ranch South wells	Specific Conductivity/TDS	Quarterly	TDS increase to 2,000 mg/L or greater	Increase monitoring frequency to monthly for 3 months and monitor 18-28, G-36; evaluate basin wide response and determine whether reduction in pumping or supply of alternative water source is warranted
Coso Junction #2, Little Lake Ranch North well	Specific Conductivity/TDS	Quarterly	TDS increase to 1,500 mg/L or greater	Increase monitoring frequency to monthly for 3 months and monitor 18-28, G-36; evaluate basin wide response and determine whether reduction in pumping or supply of alternative water source is warranted

Table C4-2 (*Continued*): Hydrologic Monitoring Parameter Summary Rose Valley Hydrologic Monitoring and Mitigation Program

Monitored Location (1)	Parameters Monitored	Monitoring Frequency	Threshold Requiring Action	Action if Threshold Exceeded
Well Yield				
Dunmovin wells, Coso Junction wells, Red Hill well, Fossil Falls Campground well	Well Yield	Quarterly	Decrease in yield of 25% or more from pre-startup levels	Mitigate well impacts per EIR Section 3.2.3 (Hydrology-2) and the Private Well Mitigation Plan
Precipitation Recharge				
Little Lake Canyon Precipitation Gauge	Precipitation totals	Daily using continuous recorder	No threshold applicable. Use data to identify basin groundwater level response (west side vs. east side) and mountain vs. valley precipitation for future numerical model updates	Recalibrate model and reassess impact to Little Lake
Haiwee Reservoir Precipitation Gauge				
(1) With the exception of Hay Ranch, every monitoring point is subject to access approval from the appropriate owner.				

Remedial Actions

The following actions are to be taken based on conditions observed during the first year of project operation:

- If drawdown trigger levels predicted **for any point in time** are exceeded in any of the selected monitoring wells, COC shall verbally report the exceedence to the Inyo County Water Department within 48 hrs, followed by a written report within 7 days.
- If drawdown trigger levels predicted **for any point in time** are exceeded in two or more of the selected monitoring points by at least at least 0.25 feet, COC shall verbally report to the Water Department within 48 hrs, followed by a written report within 7 days, followed by a re-calibration of the model and recommendation of cessation of pumping or predictions of the duration of pumping that can be sustained without causing a significant reduction in water available to Little Lake, (defined as no greater than 10% reduction in groundwater inflow); if appropriate, the Applicant may petition the County for permission to continue pumping for a specified duration. The County will evaluate the report and data, and will make a determination as to whether continued operation is appropriate.
- If predicted **maximum acceptable drawdown trigger levels** are exceeded in any of the selected monitoring points located at least 9,000 feet from both Hay Ranch production wells, COC shall: verbally report to the Water Department within 48 hrs; followed by a written report within 4 days; followed by a suspension of pumping within 7 days pending re-calibration of the model; and recommend either cessation of pumping or make predictions of the duration of pumping that can be sustained without causing a significant reduction in water available to Little Lake, (defined as no greater than 10% reduction in groundwater inflow), to be conducted within 4 weeks of the observation of the exceedance. The County will evaluate the report and data, and will make a determination as to whether continued operation is appropriate.
- If measured drawdown values in all monitoring locations at all times within first year of project pumping, match predicted drawdown plots to within 25% or less but are generally below the predicted values, then COC must stop pumping at 1.2 years. However,

they may recalibrate the model before cessation of pumping and use available data collected to date, to petition for a presumably small extension to pumping. The County will evaluate the report and data, and will make a determination as to whether continued operation is appropriate.

- If monitoring data collected during the first year show that a majority of monitoring points record drawdowns are consistently lower than predicted, then COC can re-calibrate the model and make new predictions of the acceptable duration of pumping. Evaluation and correction of background levels for each well shall be conducted to account for natural variation and to separate effects of pumping from natural effects.

The proponent will prepare monthly reports within 20 days of data collection. The monthly reports will include the calculated drawdown amounts for each well monitored. Any well that exceeds its predicted drawdown from the baseline level for the specific month monitored, will be highlighted in the report.

Quarterly reports for submittal to the Inyo County Water Department during the startup monitoring period will also be required. The reports will include tabular summaries and electronic data packages for all monitoring data, and graphical presentations including at a minimum, the following:

- Quarterly groundwater elevation contour maps;
- Quarterly total dissolved solids (TDS) or electrical conductivity contour maps;
- Time versus water level measured in monitoring wells and Little Lake; and
- Time versus Hay Ranch pumping rate, Little Lake discharge, and flow measured at the North Culvert on the Little Lake Ranch property.

The quarterly reports will also discuss any issues such as unexpected drawdown, reduced yield or flow identified with private wells or springs in the valley, or Little Lake. Any measures taken or proposed to mitigate these issues shall be discussed. At the end of the first and succeeding years of operation, if any, the proponent will prepare an annual monitoring report summarizing the findings of the quarterly monitoring reports and evaluating the following:

1) Annual groundwater extraction from Hay Ranch wells;
2) Calculated groundwater table drawdown as measured in designated wells that are monitored in the valley;
3) Evidence for impact to spring discharge and/or surface water flows at Little Lake;
4) Evidence for adverse impacts to water quality based on measured specific conductivity or TDS in springs and well waters;
5) Trends in precipitation data to establish relative “wetness” of the first year of the project based on annual Rose Valley rainfall and Sierra snow fall that might impact recharge, groundwater levels, or spring flow in the valley;
6) Seismic events, major storms, or other unusual events as applicable;
7) Comparison of groundwater levels in wells monitored near Haiwee Reservoir to water levels in wells at the north end of Rose Valley to reevaluate the fixed northern groundwater flow boundary in the numerical model;
8) Reevaluation of the specific yield, storage coefficients, hydraulic conductivity, and groundwater recharge rates of the aquifer and comparison to values used in the numerical model.
9) Evaluation of the observed relationship between Little Lake water elevation and groundwater elevation (or pressure) in Little Lake North and/or Little Lake Hotel wells; and
10) The results of the re-calibration of the model during the first year, and any subsequent re-calibrations, shall be discussed in the annual report.

Phase 3: Model Recalibration and Redefinition of Pumping Rates and Duration

Model Recalibration

Based on the data collected in Phase 2, the numerical groundwater flow model will be recalibrated by a qualified person approved by Inyo County Water Department and provided by the applicant after six to 12 months of data have been collected. The model recalibration effort will include consideration of the following:

- Estimation of aquifer specific yield, storage coefficients, recharge through model boundaries, and any needed changes to the hydraulic conductivity distribution within the model grid to more accurately simulate the actual aquifer response to prolonged pumping at Hay Ranch.
- Evaluation of hydrologic data obtained from baseline studies and monitoring at Little Lake Ranch to reassess the trigger levels for groundwater impacts on Little Lake. Evaluation of the magnitude of the hydraulic gradient from the underlying groundwater into Little Lake.
- Evaluation of correlation between seasonal groundwater level changes at the south end of Owens Valley and groundwater elevation changes in Rose Valley and any other factors deemed significant to reassess the magnitude of groundwater underflow from Owens Valley and/or seepage from Haiwee Reservoir.
- Assessment of precipitation monitoring data to identify basin groundwater level response (west side vs. east side) and mountain vs. valley precipitation.
- Reassessment of geothermal water upwelling rate, which is currently neglected in the model, based on the observed response of wells (G-36 and 18-28) completed on Navy property.

The timeframe for recalibrating the numerical model should be accelerated if observed levels of well drawdown exceed model-predicted drawdown in two or more monitoring points by greater than 0.25 feet over predicted drawdown values, within the first six to eight months of pumping; otherwise recalibration should be conducted between eight and 12 months of project operation. The recalibrated model shall be used to reassess projected impacts to groundwater inflow to Little Lake based on the maximum acceptable drawdown trigger level at Little Lake.

The maximum acceptable drawdown trigger level at Little Lake, set at 10% reduction in groundwater inflow to the lake, is estimated to be equivalent to a drawdown of 0.3 feet in the groundwater at the northern end of Little Lake; this may be revised based on new measurements of pre-pumping groundwater levels near the lake, and on new lake level data. ***Any revisions to trigger levels must be set such that Little Lake surface waters will never experience a greater than 10% reduction in inflow as a result of the proposed project.***

The recalibrated model will be used to evaluate whether, based on a more accurate simulation of hydraulic conditions in the Rose Valley, project pumping can continue to 1.2 years or longer. The recalibrated model shall also be used to establish new trigger levels for each of the monitoring wells listed in Table C4-1. The new trigger levels will be incorporated into an addendum to this plan, and again, must meet the criteria that Little Lake surface waters will not ever experience a greater than 10% reduction in inflow as a result of the proposed project. The recalibrated model and any modifications to trigger levels must be reviewed and approved by the Inyo County Water Department.

Redefinition of Pumping Rates and Duration

Pumping rates and duration will be redefined by a qualified person approved by Inyo County Water Department provided by the applicant prior to the 1 year project benchmark. Pumping will not be allowed to proceed beyond the initial year operation period until revised pumping rates and duration are approved by the Water Department.

The revised pumping rates and duration will be set to reduce potentially significant impacts to less than significant levels for the duration of the project until the period of maximum drawdown levels has passed at Little Lake.

Modeling conducted for the EIR indicated the groundwater table at Little Lake could continue to decline as a result of pumping the Hay Ranch wells for up to 30 years after termination of pumping before beginning to rise back to pre-project levels. Consequently, the analysis of revised pumping rates and duration should consider when the maximum groundwater table drawdown will occur, and how much drawdown will occur, to ensure that Little Lake never experiences a greater than 10% decrease in groundwater flow as a result of the proposed project.

Phase 4: Ongoing Monitoring, Reporting, and Mitigation Implementation

Groundwater and surface water monitoring will continue to be conducted during the subsequent years of groundwater production from Hay Ranch, according to Tables C4-1 and C4-2, above.

Groundwater Monitoring and Mitigation Implementation

Groundwater monitoring includes the monitoring of groundwater pumping rates at Hay Ranch, water elevations in designated non-pumped wells through out the valley, specific conductivity and/or TDS, and water levels and pumping rates in pumped wells within the valley as listed in Table C4-1. Groundwater elevations will be compared to the model-predicted levels annually. The need for recalibrating the numerical groundwater flow model should be reviewed for every year of Hay Ranch well pumping (or more frequently if trigger levels are exceeded, as noted previously) to ensure the accuracy of predictions of future water level drawdown.

Groundwater levels in private pumped wells will be monitored using depth to groundwater measurements from designated monitoring points located throughout the valley. When the static groundwater elevation appears to be within 20 feet of the bottom of the well or the well yield is observed to be reduced and further investigation indicates that the water level has dropped too low for an effective pump depth, the well will be remediated by COC by setting the pump deeper, and potentially deepening the well. Some wells may require more powerful pumps to compensate for lower water levels. Mitigation of impacts to private wells will be implemented as described in the Private Well Mitigation Plan, established during the 2 year setup phase (previously described).

Groundwater elevations in Little Lake Ranch well, Little Lake Hotel well, and the North Dock well, and Little Lake water levels and Little Lake discharge rates will be monitored to ensure that trigger levels are not reached for the duration of the project, as determined in Phase 3 Model Recalibration and Redefinition of Pumping Rates and Duration. Mitigation in terms of reduced pumping rates or duration of pumping and/or implementation of a groundwater diversion plan would be implemented as described in Phase 3.

Surface Water Monitoring and Mitigation

Although surface water monitoring will include the Coso Spring and Little Lake, threshold levels triggering mitigation will be focused on Little Lake. The lake water elevation, lake discharge and specific conductivity, spring discharge and specific conductivity, and occurrence of siphon well discharge will be monitored.

If agreed upon by the County, COC, and Little Lake Ranch and determined to be feasible as defined in mitigation measure Hydrology-3, a Little Lake water diversion plan will be developed during project start-up and implemented based on trigger levels throughout the valley. The water diversion plan will include additional pumping from one or more of the existing wells at the Little

Lake Ranch property, if feasible, or construction of a new well. Water will be piped from the well location to the lake where it shall be discharged. Water will be withdrawn at the minimum rate necessary to maintain lake water levels and surface water flows for maintenance of existing plant communities on the property or at the level indicated with updated modeling results.

The applicant will use biological and archaeological monitors during all ground disturbance activities associated with the construction of the augmentation plan components. The applicant will also be responsible for obtaining any required permits for the augmentation plan at the time that it is designed and implemented. The applicant will also be responsible for financing the augmentation plan for the duration that it is determined needed.

Ongoing Reporting

During the Ongoing Monitoring Phase, COC will continue to prepare monthly and quarterly reports.

An annual report will also be prepared for submittal to the Inyo County Water Department. If the Inyo County Water Department approves groundwater extraction at Hay Ranch beyond the initial year, the proponent may petition Inyo County to reduce the reporting frequency for interim reports (i.e. monthly reports). The annual reports will include tabular and graphical summaries of all monitoring data as discussed under Phase 1: Startup Monitoring. The monitoring reports will also discuss any issues identified with respect to potential impacts to private wells in the valley, such as reduced yield or other problems, and will discuss any measures taken to mitigate these issues. On an annual basis, the proponent will prepare an annual monitoring report summarizing the findings of the quarterly monitoring reports and evaluating the following:

- Annual groundwater extraction from Hay Ranch wells;
- Calculated groundwater table drawdown in wells in the valley and comparison to groundwater drawdown trigger levels;
- Evidence for impact to spring discharge and/or surface water flows at Little Lake;
- Evidence for adverse impacts to water quality based on measured specific conductivity or TDS in springs and well waters;
- Trends in precipitation data that might impact recharge, groundwater levels, or spring flow in the valley; and
- Seismic events, major storms, or other unusual events as applicable.

Based on these analyses, the annual reports will discuss the need for mitigating impacts to Little Lake, if any, and discuss any recommended changes to the monitoring plan including monitoring frequency, parameters, or locations.